HOME AND SCHOOL SERIES FOR YOUNG FOLKS

Great American Industries

·MINERALS·

A. FLANAGAN CO.
CHICAGO

GREAT

AMERICAN INDUSTRIES

VOLUME I.

COAL, PETROLEUM, IRON, MARBLE, SLATE
GOLD AND SILVER, COPPER AND ZINC.

BY

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CONTENTS

PREFACE

The subjects treated in this little volume are complete as far as it is thought the details will be of interest to pupils of grammar grades. In this, the work differs from its many competitors for public favor; it is a work of reference as well as a reader.

The facts have been gathered from the most recent and reliable sources, and are correct to date.

"Peace hath her victories no less than War." Special attention has been given to the history of these great industries which have wielded such a potent influence in giving our country its position among the nations of the world. This feature of the work makes it a valuable supplement to any school history.

Children are fond of writing, provided they have facts and thoughts to express. The author has found the subjects discussed in this volume of great interest to pupils for language exercises, and the suggestions appended to each topic are to assist the teacher in this feature of the work.

W. F. Rochelleau.

GREAT AMERICAN INDUSTRIES

COAL.

DISCOVERY AND LOCATION OF COAL.

DID you ever think what coal is and how it was formed, as you sat by your glowing grate or were whirled over the country by an express train? If not, it may be of interest to you to learn something about this great source of wealth.

Wood was the only fuel known to our grandparents, and in some sections it is still the only

one in general use. The only coal known to them was charcoal, which was used in furnaces for melting iron and by blacksmiths in their forges. It was used because it made a much hotter fire than wood. Charcoal is made by burning large piles of wood under cover, so only a small supply of air can get to the fire; the wood burns very slowly, and only the smoke and gases pass off, leaving the pure coal. The old-fashioned coal-pit was made by covering a large pile of wood loosely thrown together with boughs and earth. The fire was then kindled in a small opening left at one end of the pit. After it was well started, the opening was closed, and the fire left to gradually burn through the pile. This would sometimes take two or three weeks if the pit was large. The covering was then taken off and a huge pile of charcoal was found ready for use.

While wood was plenty and but little coal needed, this answered all purposes; but when nearly all the wood had been cut off and more coal was needed every day, people began to wonder where it was to come from. They never dreamed that in the ground, and possibly under their own houses, was so great a supply that it would take hundreds of years to use it all, even if it were used for every purpose for which heat is needed.

Although mineral or stone coal has not been in

general use but a comparatively short time, we have good reasons for supposing that it was known and used to a limited extent many years ago. One Greek historian tells us that it was used as early as 300 B. C., and it is said that coal was systematically mined in England in 1180. About two hundred years before Columbus discovered America, coal was quite largely used in London. But it burned with so much flame and gave off so much black smoke that the people thought it poisoned the air, and appealed to Parliament to stop its use. In response to this appeal, Parliament passed a law forbidding the burning of coal, and making the use of it punishable by death. About fifty years later, however, this law was repealed, and the people of Newcastle were given permission to mine coal. From that time the coal trade in England has continued to increase.

The Indians probably knew of the existence of coal in this country before America was discovered by white men, but they could not burn it well enough to make it of any value to them. In 1679, Father Hennepin, a French explorer, marked the location of a coal mine on the banks of the Illinois River, near the present town of Ottawa. We do not know whether other explorers had discovered coal before Father Hennepin or not; he was the first to make any record of the discovery.

Some of the soldiers who were in General Braddock's expedition against Fort DuQuesne, in 1755, claim to have cut through seams of coal in constructing portions of the road over which the army marched in what is now Pennsylvania, and to have burned some of the coal on their camp fires. As the country was settled, after the Revolutionary War, the existence of coal became generally known, as it was soon discovered in nearly all localities where it is found at present.

The three principal kinds of coal are anthracite, bituminous, and cannel. The anthracite is very hard, and on that account is sometimes called stone coal. Bituminous and cannel are softer, and burn more readily and with a brighter flame.

The different degrees of hardness, and the different composition of these varieties of coal is supposed to be caused by the action of heat and varying degrees of pressure. Anthracite is in all probability the coal first formed. It is deeper in the earth than the other varieties, and has been subjected to greater heat and pressure, hence it is nearer pure carbon and more compact. Anthracite passes into bituminous by gradual stages, so it is somewhat difficult to draw the dividing line between them. The bituminous coal of Pennsylvania and Ohio is harder and more compact than that of Illinois or the mines west of that state. In the states still further west,

we find a coal called lignite that seems to have been formed much later than the other varieties, and which resembles charcoal in its appearance.

Anthracite is found in Rhode Island, Eastern and Central Pennsylvania, and Nova Scotia and New Brunswick. Bituminous and cannel are found in western Pennsylvania, Ohio, Indiana, Illinois, southern Michigan, and a number of states west of the Mississippi River, but it is not extensively mined in these states at present. The area of the coal regions of the United States is one hundred and ninty-eight thousand five hundred square miles, or more than forty-one times the size of Ohio. The area of the coal fields of Nova Scotia and New Brunswick is eighteen thousand square miles. By this we see that there is more coal in the country than we can use in hundreds of years to come. The areas in which coal is found are known as coal measures.

The coal mines that were first worked in America are near Richmond, in Chesterfield and Powhatan counties, Virginia. These mines were probably worked as early as 1750. In 1775, coal was in quite general use in this vicinity, and was valuable to the Americans for the manufacture of cannon balls in the war for independence. For a long time the use of coal was limited to furnaces and blacksmiths' forges. This was because people did

not believe it could be burnt in open grates or stoves. Bituminous and cannel coal came into general use much sooner than anthracite, because they were easily ignited, and required no special grate or furnace.

We have said that anthracite is very hard. It is also somewhat difficult to ignite, and it was a long time before people learned its value. Every attempt to burn it failed. Not even the blacksmiths could ignite it in their forges, and every one thought it was worthless. At last a blacksmith by the name of Gore succeeded in igniting it in his forge, and discovered that it made a very hot fire and burned without flame. He told his discovery to others, and in a short time this coal was in general use among the smiths in the Susquehanna valley.

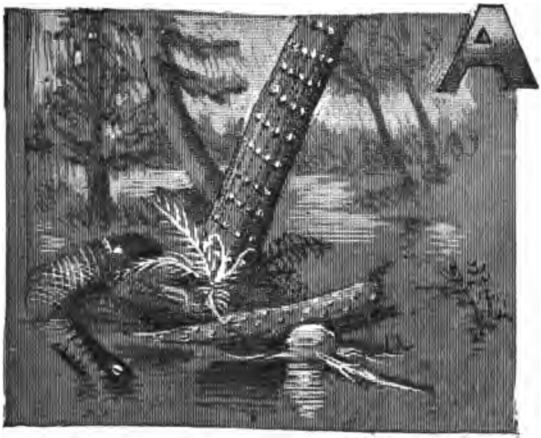
However, its combustion depended upon the blast of air driven through it by the bellows, and it was not supposed that it could be made to burn without some arrangement whereby a strong current of air was forced through the fire. The first cargo shipped into Philadelphia could not be sold, and it was with difficulty that any one could be prevailed upon to take the coal as a gift, and make a trial of it. The trials ended in failure, and all attempts to place this new fuel upon the market were given up for the time.

The secret of successfully using anthracite coal was discovered by accident. This is the way it

happened. Every one thought that the coal must be continually poked and punched in order to make it burn. An iron company purchased a cart load and attempted to use it in its furnace. They worked and poked it all day, and wasted the entire load without getting a fire. They bought another load, and resolved to work all night before they gave it up. This they did, but without any better success. In the morning they went to breakfast and left the coal in the furnace with some wood burning under it. When a workman returned he was greatly surprised to find the furnace door red-hot. He threw open the door, and discovered the coal burning with great heat. From this it was seen that the only thing necessary to ignite anthracite coal was to place it on a good bed of kindlings and then let it alone. When this was once understood, there was no more trouble, and the coal began to be used in grates and stoves as well as furnaces.

Bituminous coal would have been placed on the market much sooner than it was had there been means of transporting it. About 1810 this coal was shipped down the Susquehanna in boats and sold in Philadelphia and Baltimore, but dams were placed across the river soon after the traffic was commenced, and it had to be given up. It is only since the construction of railroads and canals that coal can be taken to all cities and towns.

WHAT COAL IS.



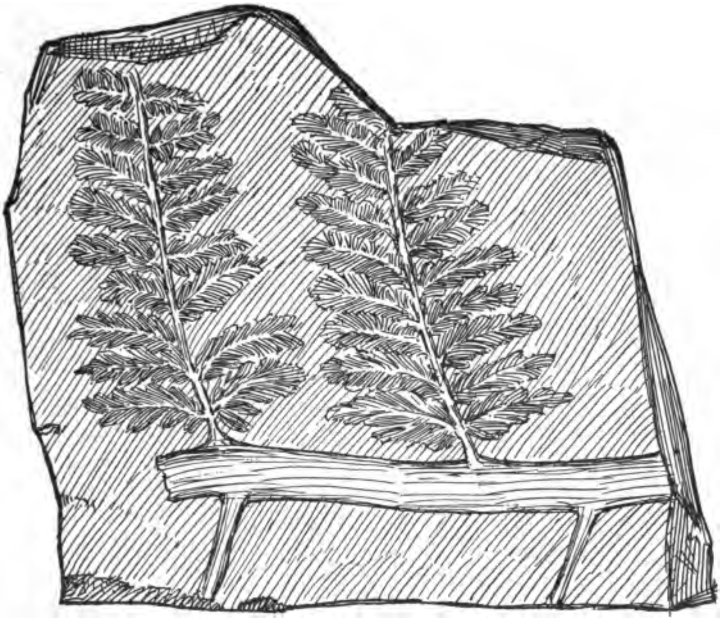
AFTER reading about the discovery and location of the coal fields, and the introduction of coal into general use, you may wish to know what coal is, and why we find it buried so deep in the earth. Let us ask the rocks, for they first told the story. Not only is the story of coal found in the rocks, but also the story of all the changes the earth has passed through from its creation to the present time. You and I may not be able to read these stories, but men who have studied the rocks all their lives can do it as easily as we read from the pages of a book. These men are called geologists, and the science which tells of the formation of the earth is geology. This is the story which the rocks tell us about coal:

Away back in the past, so many years ago that no one can number them, ages before any animals or men lived upon the land, everything was very much different from what we find it now. The earth's surface contained much more water and much less land than at present. There were no high mountains nor deep valleys such as we see, and the climate seems to have been the same all over the earth. It was very hot; much hotter than any climate known to-day. The air was filled with moisture, and contained in large quantities gas that was poisonous to men and animals. This gas was so poisonous that it could not be breathed even for a short time without causing death. This gas is called carbonic acid, or more properly carbonic di-oxide, because it is composed of two parts of oxygen to one of carbon. While carbonic acid is poisonous to animals, it is the very best of food for plants.

During this time, which is called the coal period, plants flourished in great abundance all over the land. So abundant was this vegetation that nothing can be found in the most dense forests of the tropical regions that can compare with it.

Suppose we should go out into the woods for a picnic some day and find all the ferns, and rushes, and club-mosses, and horsetails grown to tall trees with trunks several feet in diameter, and much

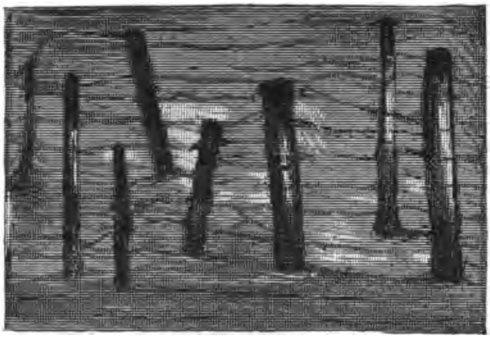
larger than any we ever saw. Suppose, again, that these trees and rushes were so closely crowded together that we could not get through them, and that the great club-mosses and other vines covered their trunks and hung down from the branches



everywhere so dense that we could not even see through them. This will help us to imagine something of how the forests of the coal period looked.

We see that the plants of our imaginary forest were much different from those found in the

forests of the present time. There were no flowers, and very few, if any, plants with small stems and delicate leaves. After these forests had flourished for a long time, some great force caused the land on which they stood to sink below the level of the sea. The trees fell and slowly decayed, and were covered with sand and mud. As the ages went by, this sand and mud turned into stone, and the heat and pressure changed the plants to coal. You see, therefore, coal is formed in very



much the same way that charcoal is made, by burning wood with a small supply of air.

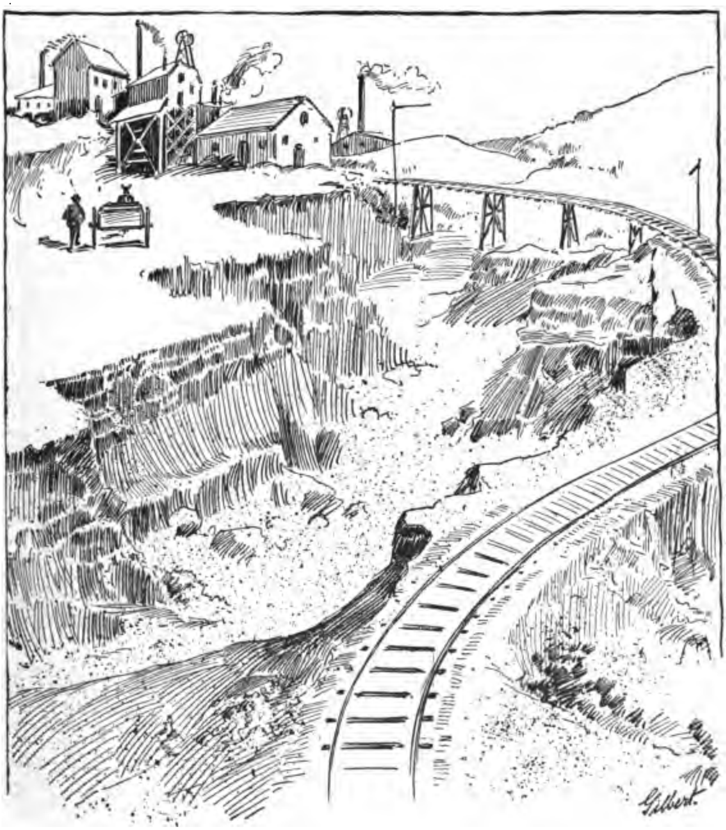
Wherever coal occurs, several layers or seams are found lying one above the other, separated by layers of rock. From this we learn that the process by which one layer was formed must have been repeated as many times as there are seams.

But how can the rocks tell these stories? Let us see. You all know how easy it is to make a perfect picture of a leaf by pressing it down on the soft surface of a piece of clay. Now, if we let the clay harden the impression will remain until the tablet is broken. So the sand and mud, falling on the vegetation that formed the coal, took impressions of leaves and stems and trunks of trees, and then hardened into stone. And there these impressions have remained through all these ages until the geologists discovered them and used them to tell this story.

Some geologists have attempted to tell how many years it took to form coal, but no one knows just how long the time was. One says that the amount of vegetable matter contained in a seam of coal six inches thick is greater than the most abundant vegetation of the present day could form in twelve hundred years. Fifty tons of stone coal spread evenly over an acre of ground will not make a layer a half inch in thickness. At this rate it would require at present seven hundred and twenty years to form a seam of coal three feet thick. This is the thinnest seam that can be worked with profit.

In the coal measures of Nova Scotia there are seventy-six seams of coal, one of which is twenty-two feet thick and another thirty-seven. The Mammouth vein at Wilkesbarre, Penn., is twenty-

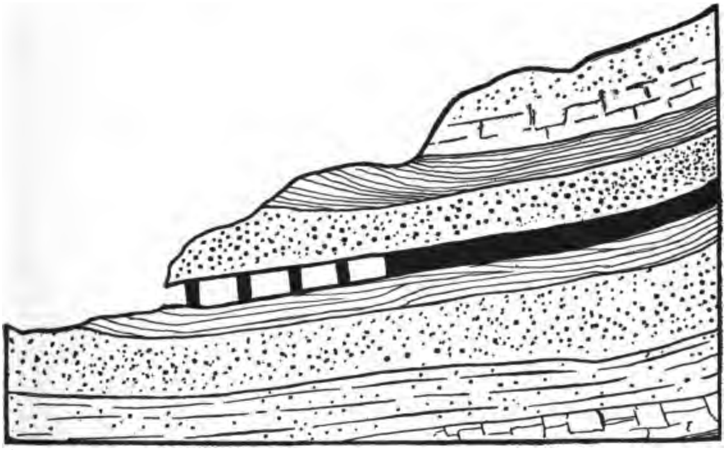
nine feet thick. If we consider that it must have taken at least as much time to form the layers of rock between the seams as it did to form the coal, the entire coal period will extend over nearly three hundred thousand years, a time so long that none of us can begin to think how long it is.



A COAL MINE.

COAL was first discovered in those seams which came to the surface in the mountainous regions. This was also the first coal used. From what we learned about the formation of coal we might think that all the seams would be found in a horizontal position, but this is not the case. The great changes that took place while the earth was being prepared for the home of man, upheaved the mountains in places where coal had been formed. By this means the coal seams were thrown up, and lie in the same position as the layers of rock among which they were formed.

Men first began to dig coal from those seams that were on the surface, and this did very well so long as only a little was used. Now the use is so general that all these seams have been exhausted, and mines are sunk deep into the earth. The depth of a mine depends upon its location and the length of time it has been worked. In the bituminous coal



STRATA OF COAL.

measures of the Mississippi Valley, the seams are in nearly the same position as when they were formed, and are found from two hundred to six hundred feet below the surface. In the anthracite regions of Pennsylvania, some of the mines extend as far as fifteen hundred feet below the surface.

When a mine is opened in an out-cropping seam it follows the seam into the earth, and resembles a

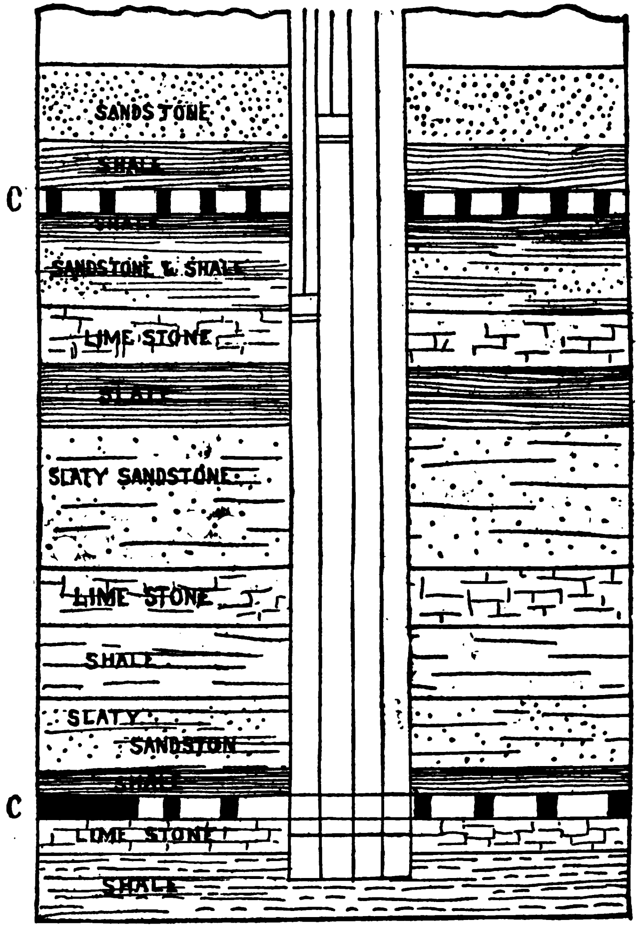
stone quarry or a cave. Sometimes it is worked into the side of a mountain like a tunnel. The tunnel is also often made in the side of a hill or mountain when the coal can be reached easier that way than by digging down from the top. Nearly all mines now worked, however, are so deep that these methods have been set aside for the shaft.

THE SHAFT OF A COAL MINE.

Perhaps you have watched the digging of a well, or a deep cellar for a large building. Well, the shaft to a mine is dug or sunk in much the same way.

It is larger than a well, but probably smaller than a cellar. A shaft of average size is twelve feet wide and thirty feet long. As the shaft sinks through the soil and soft earth, the sides are walled with strong timbers or stone to keep them from caving in. When it sinks through solid rock these walls are not needed. The shaft is sunk until it reaches the bottom of the seam which the miners wish to excavate. If the seam is tilted, the shaft is located if possible so as to sink it to the lowest point. We shall see why they do this further on.

The shaft is divided into four compartments by partitions running its entire length. These partitions are made by placing oak timbers six inches



COAL SHAFT.

C represents a strata of coal. The light parts show the coal removed; the dark, the coal left in for support.

square across the shaft and firmly fastening their ends into the walls. These timbers, called buttons, are placed four feet apart and covered with boards. This makes a strong, tight partition.

Two of these compartments are used for the hoisting carriage, one for the purpose of getting air into the mine, and the other for pumping out the water. The partition between the hoisting and air compartments needs to be air tight, otherwise the mine could not be properly ventilated. On two sides of each hoisting shaft are slender vertical timbers fastened to the middle of the partitions. These are to guide the carriage, or cage, as it is called by the miners. This gives the compartment the appearance of an elevator well, which you can see in almost any high building in a city.

A strong frame, called the head-frame, is erected over the mouth of the shaft. The height of this frame depends upon the location of the shaft and the number of times the coal must be handled before it is shipped. It is always as high as a two-story house, and often much higher. Large wheels, called sheaves, are placed on the top of the head-frame, and over these pass the wire ropes that are attached to the carriages. These ropes are connected with a drum which is operated by a powerful engine placed near the shaft. The carriages are so attached to the drum that as one is raised the other is lowered.

The carriage bears quite a close resemblance to ordinary freight elevator. To the strong platform, which forms the bottom, are fastened two strong, upright timbers, which are fitted to the guides by grooves. These uprights are joined at the top by a beam to which is attached the rope. This rope is made of wire and is very strong. A covering, called the hood, is also fastened to this beam. This is to prevent anything that should happen to fall into the shaft from injuring those who may be on the carriage. A track is placed on the platform in such a direction as to make it continuous with that in the mine when the carriage is at the bottom of the shaft, and with that on the trestle when it is on the head-frame.

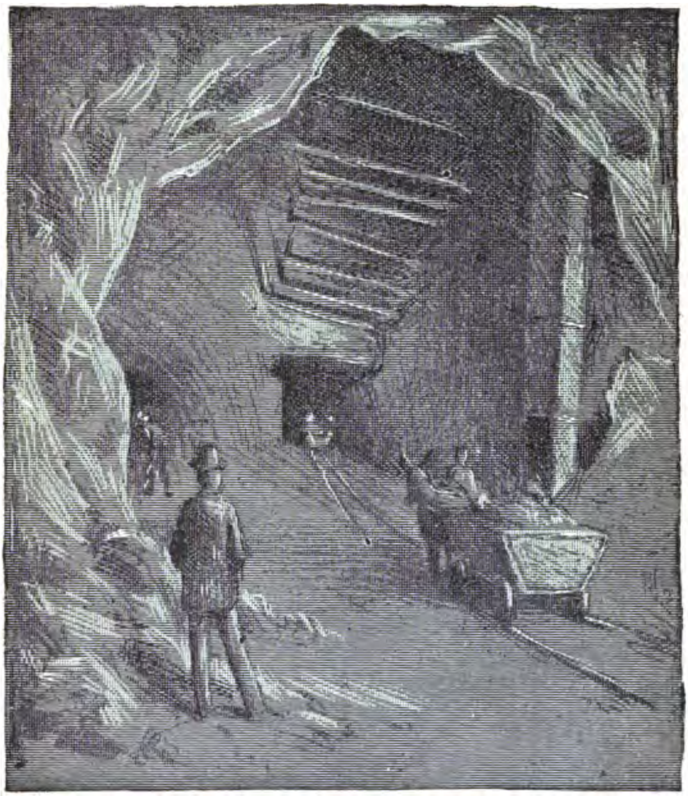
Now we have learned how the shaft is constructed and operated, we will next study the mine.

THE PLAN OF A COAL MINE.

LET us put on a miner's suit, take each a miner's lamp, and, attended by a guide, place ourselves on the carriage and descend into the regions below. As the carriage begins its descent, and the walls of the shaft seem to fly upward, we may feel fearful of the outcome of our journey, and wish we had not started. The writer has known this to happen when parties were making excursions into a mine. But we do not have much time to think about it before the carriage suddenly stops, and here we are!

Our guide hurries us off the carriage that it may immediately return with its load of coal. How dark it is! We have been out on the darkest night, but have never before known such darkness as this. We can scarcely see anything, even with the light of our lamps. The guide asks us to be

seated on a bench near the foot of the shaft for a few minutes, until we can become somewhat acquainted with our surroundings. We hear



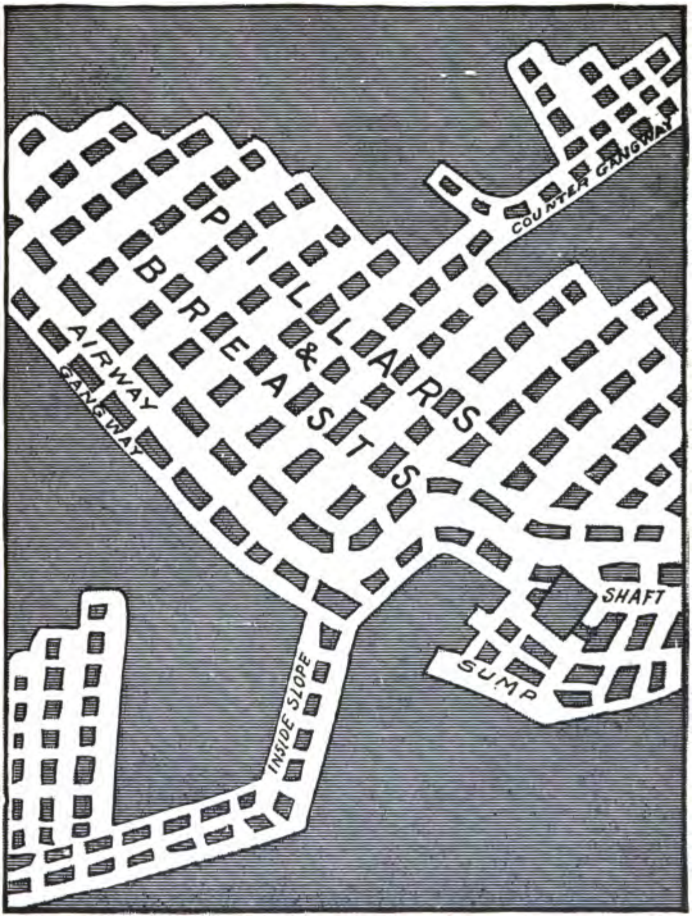
VIEW IN A COAL MINE.

strange sounds all about us, but cannot tell where they are. The rumbling of machinery; the rattle

of cars; the shouts of the drivers; the crack of the miners' drills; and the dull heavy roar of a distant blast, all make us think that we are in another world.

The first thing that attracts our attention is the row of lights twinkling and dancing down the long, dark passage way. This passage is the main entrance to the mine, and is called the gangway. It contains the track over which the cars pass on their way to and from the shaft. Running along beside the gangway and parallel to it, is another passage called the air passage. This is for the purpose of carrying pure air to all parts of the mine. Crossing the gangway at right angles, and at short distances from each other we shall find passages leading to the chambers where the miners are at work. If the mine has been worked for a long time, we shall find other gangways crossing these, so that all together the passages excavated in a coal mine resemble the streets and alleys of a city. The only difference is that these passages are not regularly laid out, for they must follow the seam of coal, and that may be very irregular.

Now we have become accustomed to the darkness, we will begin our exploring trip. As we pass the lights that first attracted our attention, we notice that each one is fixed to a miner's cap. This enables the miner to carry his light and have



PLAN OF COAL MINE.

both hands free for work. As we move along the passages we notice that great pillars of coal are left

every few feet to support the roof of the mine. In addition to these, hard wood posts are also used in many places. The pressure from above is so great that the miners have to take the utmost care to prevent the roof from caving in. Sometimes all the supports are crushed, and great masses of rock fall into the mine. If this happens during working hours, the poor miners are liable to be crushed by the falling rock, or cut off from escape, so that they perish from suffocation before aid can reach them.

All along the passages, and in many of the chambers we see tracks that connect with the one in the main gangway. By this arrangement the cars may be placed in all parts of the mine, and the coal loaded where it is taken from the seam. If the mine is level these tracks may be constructed wherever they are needed, but if it slopes the tracks are placed only in those gangways that are on nearly the same level as the foot of the shaft. The coal is then slid down to the gangway by a shute, or is taken out by a small car called a buggy. We can now understand why the shaft is sunk to the lowest point in the seam. It is much easier and cheaper to slide the coal down to the gangway and then hoist it from a greater depth than it is to work it up a slope in the mine. The water also runs to an excavation made for it

near the foot of the shaft, and called the sump. In this way a mine can often be drained by a single pumping station.

THE WORK IN THE MINE.

Our guide has been explaining all these things as we walk along the passages, and now we find ourselves in one of the chambers where the miners are at work. Here are four men—two of them are miners and two are laborers. The miners are partners and make a contract with the coal company to receive a certain price for every ton of coal mined by them. These miners furnish their own tools and hire their laborers. Their powder, oil, fuse, etc., is furnished by the company and charged to their account. The two miners divide their wages equally with each other and are called butties. "Butty" seems rather a strange name for a business partner, does n't it? The miner's duties are to loosen the coal and set the props so as to protect the roof of the chamber. The laborers must load the coal into the car and clean away the refuse so the chamber will be ready for work the next morning.

The coal is loosened with a pick or by blasting. When making an entrance into a chamber, the space is often so narrow that the drill cannot be

used. Then the pick is resorted to until enough coal has been removed to admit of drilling. The drills are of two kinds—the common hand drill and the machine drill. This may be so arranged that it can be driven by hand or by steam or compressed air. This last method is very common in bituminous mines, but in the mines where anthracite is found it does not work well, as it breaks the coal into small pieces and causes waste.

The miner prepares his blast by first drilling a hole about five feet deep, cleaning it out, and placing a cartridge of black powder in the farther end. He then arranges to connect the fuse, or squib, as he calls it, and fills the hole with moist earth, driving it in hard with the end of his drill. This is called tamping. When the tamping is completed he is ready to fire the charge. As we have watched these preparations, we begin to think it is about time for us to visit some other part of the mine, but our guide asks us to remain and see the effect of the blast. He conducts us behind some pillars at a safe distance and we await results.

The miner shouts "Fire!" several times, to warn any one who may be coming to his chamber, lights the fuse and runs behind a pillar. Presently we feel a puff of air, hear a dull roar, have our eyes and mouth filled with fine dust, and realize that the blast has been discharged. As soon

as the dust has settled, we return to the face of the chamber and notice that a good quantity of coal has been loosened. The miner begins drilling another hole, and keeps on blasting until he has loosened as much coal as will be needed for the day. His work is then through, and he can leave the

MINERS AT WORK.

mine, but the laborers must stay until they have everything ready for the next day's work.

If his work goes well, the miner is usually ready to leave by noon, and sometimes sooner. You see that he does not have a long day's work, but we must not judge it to be a very easy one by that. He often has to work in such positions as to make a

few hours labor very tiresome, as you can see by looking at some of the cuts showing miners at work.

When the laborers have loaded the car it is pushed out of the chamber, and a driver draws it to the shaft. These drivers are boys. Each boy has charge of a mule, and both mule and driver become so familiar with the passages that they never take the wrong one, and seldom meet with accidents. As the car nears the shaft the boy unhitches the mule and he dodges into a side passage and lets the car pass. In some mines the mules are kept in underground stables, and never go out. In others they are taken out every night. The mule places himself on the carriage with his driver and is hoisted to the surface with as little concern as the miners. In the mines of England ponies are used instead of mules, and in some of the large mines in this country small locomotives and electric engines are used to draw the cars along the gangways.

Besides the miners and drivers, we find several other classes of workmen in the mine. There are the door boys who open and close the doors as the miners and cars pass through. These doors are made in partitions placed across some of the passages to change the direction of the air currents, and must be tended very carefully, as the safety of the miners depends upon the free circulation of air

to all parts of the mine. We also find track layers, carpenters, and sometimes engineers.

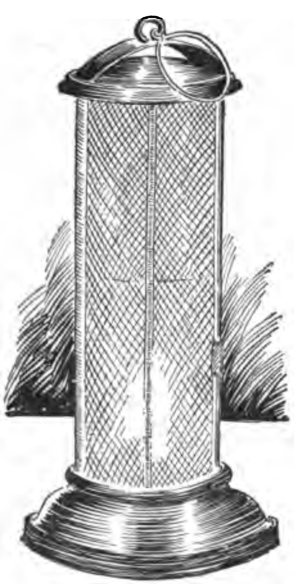
The principal officers of the mine are the mine boss, the fire boss, and the driver boss. The mine boss is at the head and is responsible for the working of the mine; all others are subject to his orders. The fire boss must look after the gas that collects in the chambers and see that it is expelled, and caution the miners to guard against it. He also attends to the ventilation. The driver boss looks after the driver boys and mules.

DANGERS OF THE COAL MINE.

The strange feeling that came over us as we entered the mine has by this time partially passed off, but we do not feel perfectly safe. We ask the guide if mining is very dangerous work, and in response he tells of the dangers that the miner must meet every day. We have already spoken of the danger that may occur by the falling of the roof, but there are others of a far different nature. The gases known as fire-damp and choke-damp are the source of the greatest danger to the miner, for he can neither hear nor see them, and may come upon them when he least expects to.

Fire-damp, as it is called, is very explosive, and when brought in contact with a light explodes with

such violence as to cause death to those who are near, and sometimes do great injury to the mine. This gas escapes from the newly worked surfaces, and is liable to accumulate during the night. To prevent accidents, the fire boss goes into the mine and examines all suspected places in the morning before the miners commence work.



DAVY SAFETY LAMP.

So many lives were formerly lost by explosions of this gas in the mines of England that a great scientist, Sir Humphrey Davy, invented a lamp to protect them. This is called a safety-lamp. It looks very much like an ordinary lantern, and the principal difference is that a fine wire screen takes the place of the glass globe in a lantern. If the gas takes fire within this screen the flame will not pass out between the wires for some minutes, and the miner is warned and can make his escape. If we are to explore any new or unused parts of the mine, the fire boss precedes us to test for the presence of this gas before we are allowed to enter with our lights.

We may be taken to a chamber where a small quantity is found and lighted for us. After having once seen this done, we never forget the danger the miners are constantly facing. The guide asks us to stand at the entrance to the chamber, and leave our lamps back far enough to ensure safety. He then takes a lighted candle and places it on a long stick, and reaches up to the top of the chamber, and a great mass of blue flame rolls along the roof with a noise like distant thunder. We conclude that, if a small quantity of this gas can cause such an explosion, that from a large quantity must be terrific indeed.

The choke-damp is formed by the burning of fire-damp, and settles in the bottom of the mine. It will not burn, and is so poisonous that a person breathing it will live but a few minutes. Miners are sometimes suffocated by this gas before they realize its presence. It may be discovered by lowering a lighted candle into the place where it is supposed to be. If present the candle is extinguished.

Besides the dangers already mentioned there is another from blasting, and from falling rock and coal in the chambers where the miners are at work. So we see that the miner must use great care in every thing he does. Smoking is not allowed, and the careless use of lamps is constantly guarded against by the bosses.

We have been so interested in the work around us, and in the explanations given by our guide that we have failed to notice the roof of the mine. But before we return let us examine the ceiling of some of these chambers, for the ceilings of the finest king's palace were never half so beautifully frescoed as are some of these underground chambers. If the coal dropped from the layer of rock

SHAFT AND PLANT.

SHAFT. REVOLVING SCREEN HOUSE. WASHER.

without breaking its surface, we find there the most delicate tracings of the leaves and stems of those plants from which the coal was formed. These are often so interwoven as to make the most beautiful patterns imaginable. Remember it is by these and other fossil remains that the geologists have been able to read in the rocks the story of coal formation.

PREPARING THE COAL FOR MARKET.

The workmen in the mine load the coal just as it is loosened from the vein. When the mine car reaches the head of the breaker it is run to the dump shute and dumped. This shute is made of long, paralled bars of iron, placed four inches apart, and inclined so the coal will readily slide over them. The small coal, dirt and pieces of rock fall between the bars into a bin called the hopper. The large pieces pass on to the breaker. This is a machine for crushing the coal, and consists of sets of strong iron rollers with teeth projecting from their surface. The rollers are so arranged that the teeth of one fit into a hollow in the one opposite. There are usually two sets of rollers in a machine. The upper set has large teeth placed far apart, and breaks the coal into large pieces. It then falls to the set below, and is crushed into sizes suitable for use.

After the coal has passed through the breaker it is screened, so that each size is separated out and placed by itself. Narrow seats are placed across the shutes leading from the breaker, and boys sit on these to catch and throw out the pieces of slate and other rock that may have been brought up with the coal. These boys become very skillful at their work, and will throw out a score of pieces of rock

when you or I could not see one. But in the last few years a number of machines have been invented which do this work better and cheaper than the boys can, so we may soon expect to find the picker boys, as they are called, put at other work.

There are several sizes of anthracite coal found upon the market. Taken in order of their size, beginning with the largest, they are lump, steamboat, broken, egg, large stove, small stove, chestnut, pea, buckwheat, and dirt. The egg, stove, and chestnut are the sizes we see most frequently, as they are burned in our stoves and grates. Coal finer than the buckwheat is not usually considered suitable for fuel. In some of the countries of Europe, however, and on some of the railways in the Eastern States, dirt coal is used by being made into bricks. This is done by mixing the coal with a preparation of pitch which sticks the particles together.

Bituminous coal is so soft that it is not necessary to run it through a breaker; in fact one of the great sources of waste in mining this coal is found in the amount of dirt formed. When a car of bituminous coal comes from the mine it is usually loaded directly on to the cars or boat to be shipped to market. Some mines have a washer to which the dirt and small sized coal is sent, and separated and washed. After washing, the coal is screened

the same as in the breakers. This washed coal is clean, and makes an excellent fuel. There is such a demand for it that those mines having washers are scarcely able to keep up with their orders.

MARKETING THE COAL.

Coal is taken to market by both cars and boats. Shipping by boat is much the cheaper, and the coal companies employ this method wherever they can. We see immense coal docks on the wharves of all our large cities. Here we find about the same devices for handling the coal as we found at the mines. Workmen are constantly engaged unloading the coal from the boats and re-loading it on to cars. This is done because it is cheaper to freight the coal by boat as far as possible and then change it to the railway than it is to freight it from the mines to the interior of the country by rail. The coal for the great cities of the Atlantic sea board reaches them by the way of canals, rivers and the sea. That for the Western states by the way of the Great Lakes and the railways leading from Chicago, Milwaukee, and Duluth. The price of coal depends very much upon the expense of freight in bringing it to us. If the people of Chicago could buy their anthracite coal right at the mine it would not cost them much more than half what they now pay for

it, and the price to the inhabitants of Duluth, St. Paul, and Minneapolis is about three times what it is at the mines.

SOME USES OF COAL.

We are all familiar with the most common uses of coal; we know what a hot fire it makes, and how it warms our houses and makes the steam that drives the great engines of commerce. Have we ever thought how strong it is? King Coal is a real giant; there seems to be no limit to his strength, and some one has called him "the giant spirit of all work."

The strength of coal has been estimated by an English engineer, and he says that the steam produced by one pound of anthracite coal, if used in an engine, will do as much work as can be done by a strong, healthy workman in one day. A bushel of this coal weighs about eighty-five pounds. From this we can see that the coal burned in our stove on a cold day in winter will do as much work as fifty men. If we were obliged to suddenly stop the use of coal, the manufactures and commerce of most of the world would be ruined. Coal turns the wheels of our factories, whirls us across the country in the rushing train, and drives the great steamers over the sea.

But there are other uses of this valuable product that we may never have thought of. A great deal of bituminous coal is made into coke by about the same process as wood is made into charcoal. The coke is used in furnaces for smelting ores and metals. The gas that lights the streets and homes of our cities is also made from this coal, by distilling it in large iron retorts. Besides the gas we get a liquid from which ammonia is made, and coal-tar from which come a number of useful articles. The most important of these are the beautiful aniline dyes used in coloring dress goods and ribbons, and paraffine, a white wax, from which candles are made. When you study chemistry you will learn all about these substances and how they are made.

Now that we have learned about the discovery of coal, its early use, and the great value it is to every one at the present time, we are prepared to read what one of our greatest poets, William Cullen Bryant, wrote about it a long time ago.

Dark anthracite that reddenest on my hearth,
  Thou in those islands didst slumber long;
But now thou art come forth to move the earth,
  And put to shame the men that mean thee wrong:
Thou shalt be coals of fire to those that hate thee,
  And warm the shins of all that underrate thee.

For thou shalt forge vast railways, and shalt heat
  The hissing rivers into steam, and drive
Huge masses from thy mines, on iron feet,
  Walking their steady way, as if alive,
Northward until everlasting ice besets thee,
  And South as far as the grim Spaniard lets thee.

Thou shalt make mighty engines swim the sea,
  Like its own monsters—boats that for a guinea
Will take a man to Havre—and shalt be
  The moving soul of many a spinning-jenny,
And ply thy shuttles, till a bard can wear
  As good a suit of broadcloth as the mayor.

SUGGESTIONS: Compare a piece of charcoal with a piece of wood and tell how they resemble each other.

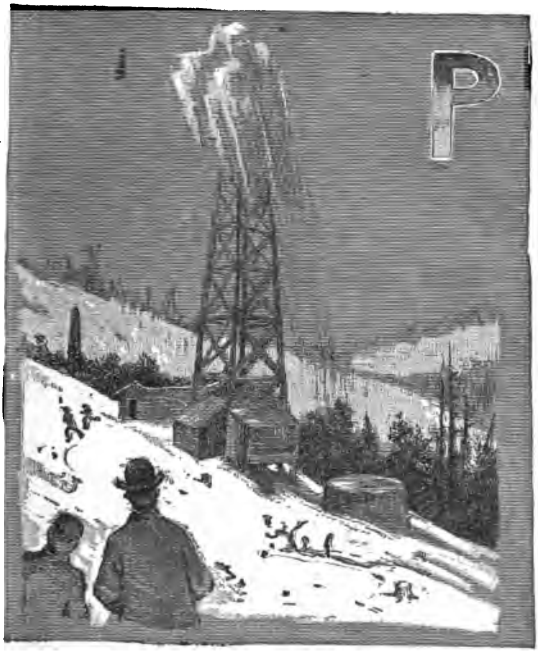
Find as many kinds and sizes of coal as you can, and see if you can name them correctly.

Examine a piece of anthracite coal with a magnifying glass, and describe what you see.

Write an imaginary description of a coal mine.

PETROLEUM.

DISCOVERY AND LOCATION OF THE OIL FIELDS.



PETROLEUM comes from two words; a Greek word, petra, meaning rock, and the Latin word, oleum, meaning oil. The name means rock-oil, and is applied to a class of substances that have nearly the same composition and products as bituminous coal, and are found in almost every country of the world.

Petroleum, under one form and another, has been known since the earliest times. It is often referred to in the Old Testament, and was without doubt the substance used by Noah to make the Ark water-tight. The oldest known oil wells are in Burmah, on a small tributary of the Irrawady. The oil from these wells has been used by the inhabitants of the country to light their houses for centuries. Japan produces about two and a half million gallons a year, and Baku, in Russia, has a very productive field, small quantities have also been taken from Peru during the last few years. But the greatest petroleum regions of the world are found in the United States.

The discovery of petroleum in large quantities in the United States was first made by Col. E. L. Drake, of Titusville, Penn., in 1859. The existence of an oily ill-smelling fluid that oozed from the rocks was known to the earliest explorers and settlers of that portion of the states in which the oil fields are located. It was also known to the Indians, who, in a pow-wow given to entertain the French at Fort DuQuesne, set fire to it in the seams of the rocks and on the surface of a small creek, dancing in its light. The Indians also valued it for medicine, and in this way it was first used among the early settlers. It was considered a remedy for rheumatism, and was known as Seneca Oil, as its

use was first made known by the Seneca Indians. The Indians collected the oil by spreading their blankets on the surface of the creeks where it floated and then wringing the oil out of them.

Some years before Col. Drake's discovery, a company began the manufacture of a liniment under the name of Seneca Oil, and it had an extensive sale. The company was in need of more Seneca Oil than they could collect by any means at hand. Col. Drake told them that he believed more oil would be found by digging into the earth, and the company furnished the money for his first well. At the depth of about sixty feet the well struck oil, and began to flow, but at this time no one supposed it could be used for the purposes of lighting and heating.

Col. Drake's well yielded 2,000 barrels the first year, and the next year two other wells were bored and the yield amounted to 500,000 barrels. In 1861 the yield was over 2,000,000 of barrels, and in 1863 it was over 3,000,000. From that time to the present the amount of petroleum taken from the earth each year has increased, until it now amounts to over 60,000,000 of barrels of forty-two gallons each a year.

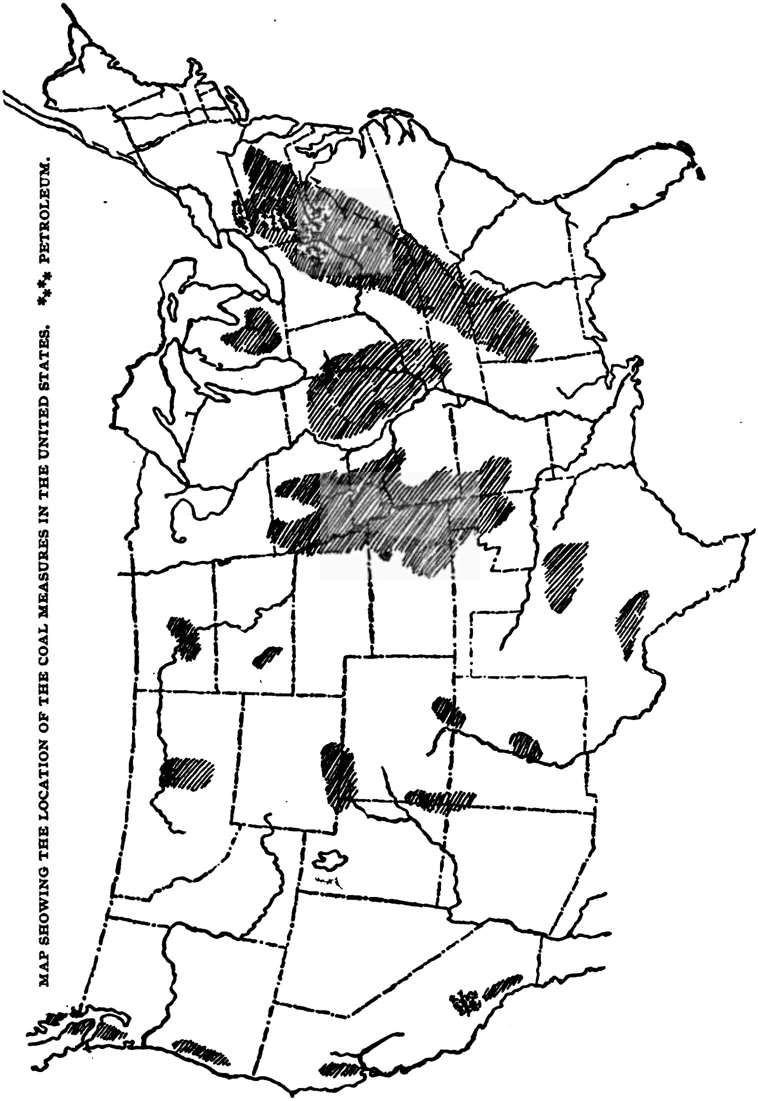
This discovery of petroleum and its rapid introduction into use caused almost as much excitement in the northern states as did the battles of the great

Civil War which was then in progress. Our histories seldom mention this great discovery, yet petroleum has done as much for the country in one way as the war did in another.

The discovery and development of this industry was in a little section of country about one hundred and fifty miles long and less than twenty miles wide, and located in the northwestern portion of Pennsylvania. Men rushed to this section from all parts of the country, as they have rushed to those places where gold has been discovered. The oil region was wild with speculation. Men went to bed poor and awoke to find themselves rich. Farms that were considered worthless rose in value until they sold for $500 and $1,000 an acre, and the owners of the land often made more money than the seekers for oil.

Geologists early made a careful study of the rock which contained the oil, and were soon able to tell with certainty where it could be found. But the oil speculators would not heed their warnings, and many of them put their money into holes in the ground, and—there it is to day.

While petroleum has been found in nearly every state in the Union, there are only a few localities that produce it in sufficiently large quantities to pay for working. These localities are known as the oil fields, and, as far as dis-



MAP SHOWING THE LOCATION OF THE COAL MEASURES IN THE UNITED STATES. *** PETROLEUM.

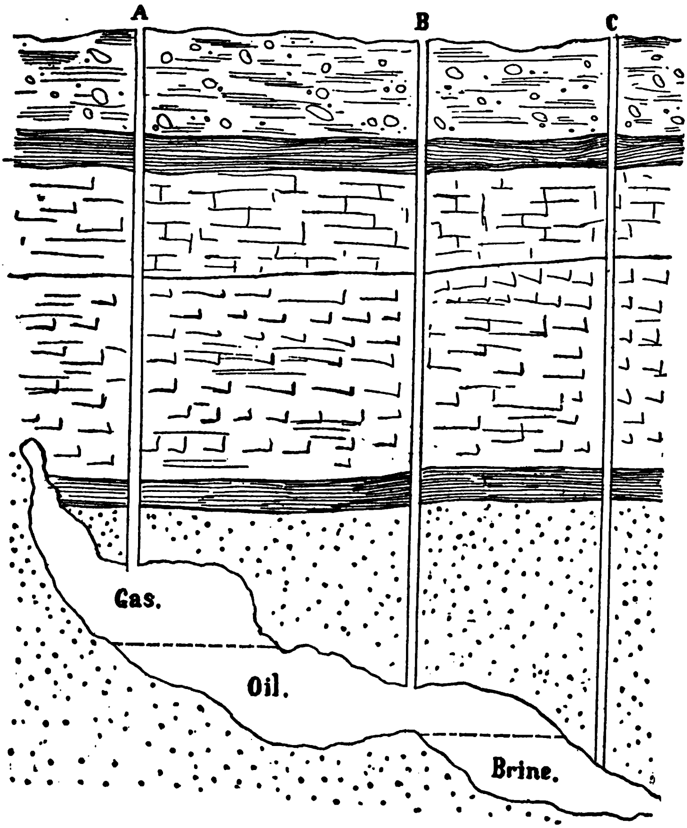
covered, are located in western Pennsylvania and New York; West Virginia, in and around what is known as the Turkey's Foot; around Macksburg and Lima, Ohio; near Florence, Colorado; in Southern California, and near Beaumont, Texas. The oil is not evenly distributed over these fields, but occurs in places in the rock called pools. If a well is bored to one side of these pools it will not yield any oil, and is a dry well.

FORMATION OF PETROLEUM.

We do not know as much about the formation of petroleum as we do about that of coal. The fossil remains of the Coal Period have left no doubt in the mind of the geologist as to the origin of coal, but no such remains can be found in connection with oil. Petroleum exists in definite localities of small area, and usually in the vicinity of the coal measures. Still it is generally believed that it has not been formed from the coal. Quite a number of theories have been given to account for the formation of petroleum, and, while they all differ in many particulars, they pretty generally agree that it has been formed from plants and animals buried in the earth.

There was a time before the coal period when the waters swarmed with fish and a class of

animals called mollusks. These animals were much more numerous then than now, and



STRATA OF OIL AND GAS.

they were also a great deal larger than any animals of a similar kind found at the

present time. The bodies of these animals were rich in substances that are found in the petroleum. We can prove this by taking the bodies of several fish and shell fish and placing them in a retort and distilling them. The substance obtained is almost exactly like petroleum.

It is supposed that during the changes which took place on the earth these animals were buried to a great depth, then distilled under the great pressure. The vapor formed in this way arose until it came to cooler rock, where it was changed to a liquid, in case of petroleum, or left as gas, in case of natural gas. This process may have gone on very generally over the earth, but oil is found only in those places where the arrangement of the rocks was just right to hold it.

Abundant fossil remains of fish and mollusks are found in the rocks below those in which the petroleum occurs and this tends to prove the correctness of the theory.

Several conditions are necessary to the collection of the oil in a chamber, or pool, as oil men call it. The first is a rock bottom that is oil-tight, so the oil will not leak through; the next is a means by which the vapor can enter the

pool; and the third is a roof that is air-tight, so the oil will not evaporate. The failure of any one of these conditions will prevent the collection of oil, and this probably accounts for the small areas in which petroleum is found. The pool may be a hollow place in the rock filled with the oil, or it may be filled with sandstone that is saturated with it; in either case, when a well is sunk into the pool, oil will be obtained.

Most pools contain oil, natural gas, and water. The gas is at the top, the oil next, and the water at the bottom. A careful study of the diagram will help us to understand this arrangement, and also to see how it is that sometimes a well yields gas, sometimes oil, and sometimes water. The oil and gas are forced into the pools under great pressure, and this causes them to burst out with violence when the well reaches them.

BORING WELLS.

As we have referred several times to the wells in the oil regions, we will now describe the process of boring them. This is the same as that for an ordinary artesian well. A derrick about seventy feet high is first erected over the place where the well is to be bored. To the

top of this derrick are fastened the pulleys over which the ropes that operate the machinery are to pass. One of these ropes connects with the drill or auger, and the other with the sand pump. The other end is attached

DRILLING AN OIL WELL.

to windlasses by means of which the drill and pump can be lowered into and hoisted out of the well.

An engine is placed near the foot of the derrick and covered with a rude shed. This engine is attached to a machine called a

walking-beam, which is used in working the drill. It is also arranged so it can operate each of the windlasses. The walking-beam is a large beam balanced on a short axle at its middle point, and has one end attached to the engine by a crank, and the other to the drill. By this means the engine drives the drill up and down, and causes it to work its way into the rock. The drill usually weighs with its attachments fifteen hundred pounds, and does not need any hammer to sink it into the rock.

Every six feet, or oftener, the drill is hoisted out, and the sand pump is used to clear the well of crushed rock. This pump is a cylinder about four feet long with a bottom that opens upward. When it is lowered into the well its weight causes it to sink into the pulverized rock, and when the operator begins to raise it the weight of the rock within closes the bottom down tight so it is brought out full. Several cylinders of sand and rock are taken from the well at each cleaning. The drill is then replaced and the work goes on. When the drill becomes dull it is taken off and sharpened at a forge in the engine house.

The diameter of the well is usually six inches. As soon as it has sunk two or three hundred feet a six-inch pipe is run down to prevent the

water from filtering in. This pipe is called the lining. When the well reaches the pool, the gas and oil often burst forth with such force as to drive the drill up into the derrick. A two-inch pipe is now run down into the pool, and the space between it and the lining is packed by a seed-bag or a rubber packing. The seed-bag is a bag filled with flax seed. The seed soaks up the oil and swells so it makes a very tight packing. This was the packing first used, but rubber has now taken its place in most instances. The small tube is connected with a tank which receives the oil, and the well is completed.

The cost of a well depends upon its depth and location. A well on the side or top of a high hill will cost more than one in a valley in the same locality, for it will have to be as much deeper as the hill is high, and the expense of getting the machinery in place will also be greater. Wells usually cost $3,000 or $4,000 including the machinery necessary for working them. If the well does not strike a pool, or is too poor to pay for working, the owner loses from $1,000 to $1,500, as he has his machinery to use on another. Wells vary in depth from four hundred to two thousand feet.

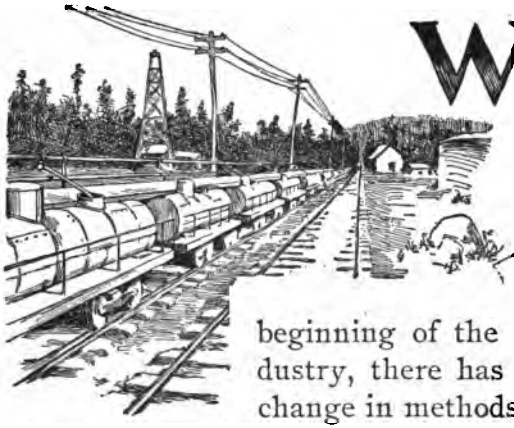
THE DIFFERENT KINDS OF WELLS.

As stated at the outset, no business is so uncertain of results as boring for oil. The well may be located in the right place and yield a good flow, or it may be located to one side of the pool and turn out a dry well. In this case all the expense of boring is lost. If the well strikes the pool at its highest point on the roof, it makes an opening into the gas, and becomes what is called a blowing well; that is, it gives off a stream of gas, and no oil can be obtained from it until the gas has been exhausted. If it strikes the pool below the level of the oil, it opens into the water, and a flow of water is obtained instead of oil. This water is sometimes very salt. In case water is struck, oil can be obtained after enough water has been drawn off to let the oil down to the foot of the well. In the diagram on page 51, *A* is a blowing well, *B* a well flowing oil, and *C* a well flowing water. The flow of the wells is caused by the great pressure under which these substances are confined. As the flow continues, the pressure becomes less, and wells that flow several thousand barrels a day when first opened have to be pumped in the course of time, and finally abandoned altogether.

When the well ceases to flow it is "torpedoed." This means that a charge of nitro-glycerine is exploded in it to loosen up the rock and enable more oil to escape. Torpedoing is very dangerous and has to be done with the greatest of care. A tin tube holding from twenty to fifty quarts of the explosive is lowered into the well and then exploded by means of a percussion cap. No sound is heard, but the ground usually heaves, and a flow of oil quickly follows. The torpedo man can be seen in every oil locality. He carries his dangerous liquid in a can in a light carriage, and one is likely to give him a wide berth. Sometimes by careless driving he strikes the wheel of his carriage against a stone, and an explosion follows. In this case, we are told, there is never any occasion for a funeral, as not enough can be found of either man or team to bury.

When the pool has been exhausted the wells become dry, and the field is abandoned. This accounts for the continual moving of the oil industry. In 1893 there was a great increase of business in new territory, and a great decrease in the old. Many have supposed that we were near the end of the oil supply, but recent discoveries in Colorado, Southern California and Texas, and the prospects for opening up still other territory, have done away with that fear for the present.

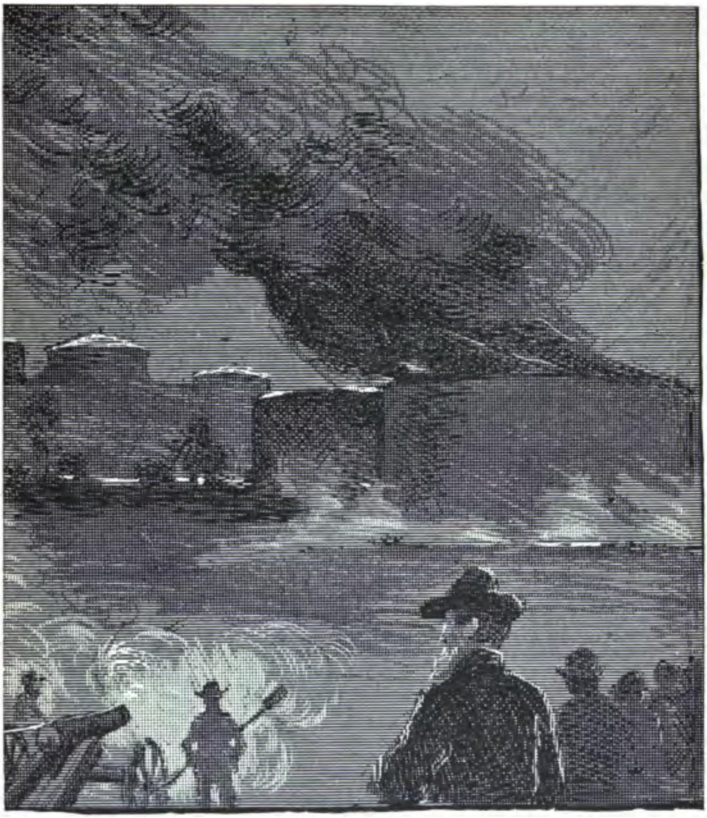
TRANSPORTATION.



WHILE the methods of sinking and piping wells have changed but little since the beginning of the petroleum industry, there has been a great change in methods of transportation. When the oil comes from the well it is stored in a tank near by. If the same company own several wells near together, they may all be connected with one large tank. From this tank the oil is taken to the refinery. At first it was transported in barrels, but this was both expensive and inconvenient. Iron tanks soon took the place of barrels on boats and railways. The railway tank looks like a huge steam boiler, and is a familiar object in all large towns, as it is used to take the refined oil to the dealers, as well as to take the crude from the wells to the refineries.

The most marked advance in transportation was made when the great companies decided to lay

pipes from the oil fields to their refineries in the large cities. These pipe lines, as they are called,



BURNING TANK.

are laid by first connecting all the tanks of one oil field by pipes and then running these into one

large pipe line which leads to the city, often several hundred miles away.

These pipes are laid on the surface of the ground and follow the hills and valleys. They are constructed of strong iron tubing, so they will withstand great pressure. Pumping engines are placed at convenient intervals to force the oil along on its journey. By this means oil can be transported quicker and cheaper than any other article of common use. Pipe lines now connect the oil fields with Cleveland, Baltimore, Philadelphia, New York and Chicago. Some of these lines are more than three hundred miles long, and the Standard Oil Company alone has more than four thousand miles of pipes now in operation.

The large tanks at the storage stations sometimes take fire and cause a great deal of damage, besides being very dangerous. When such a fire is started, and there is danger of the tank's exploding, a cannon is brought out and holes shot in its side so the oil can run out. If the tank should explode it would be liable to destroy all the tanks in that locality, and the danger from such a flood of burning fluid cannot be estimated.

The evaporation of the oil is a source of waste that has to be carefully looked after by all who handle it. On this account merchants usually keep their kerosene in tin or iron tanks, and often

have special delivery wagons for the purpose of taking oil to their customers. The wagons are tanks like those on railways, only smaller, and placed on a set of wheels, so they can be driven about the streets. They are a convenience to those using the oil, and a saving to the merchant.

REFINING.

The oil that comes from the wells is called crude petroleum. It is of a dirty brown color, and gives off a very disagreeable odor. Crude petroleum contains many impurities that must be removed before it is ready for use. The removal of these impurities, and the separation of the various substances found in the crude oil is called refining. Distillation is the first process in refining crude petroleum, and distillation is separating one liquid from another by heat.

Let us make a small still and see how it works, then we can understand the large ones of the oil refinery. We will take a bottle with a large neck—a horse radish bottle will answer—and fit a cork to it tightly. Then we will place a piece of glass tubing through the cork, and connect that with several feet of rubber tubing that is small enough to tightly fit over the glass tube. Now put some

molasses and water in the bottle, run the rubber tube through a dish of cold water set low enough to allow the liquid passing through it to flow into a cup. Place the bottle in a basin of water and set it on the stove, and our still is complete and ready for use. If we are careful to heat the mixture in the bottle slowly, we shall find that the liquid which collects in the cup is pure water. The molasses does not boil at as low a temperature as the water, so is left in the bottle.

What our still does on a small scale, that of the refinery does on a large one. The oil still usually is an iron tank holding 1,200 barrels. The tube at the top is connected with a coil of pipe that passes through a tank of running water to keep it cool. The crude petroleum is placed in this tank, and a slow heat applied. Those substances that evaporate at a low temperature pass off first, then those that require greater heat. In this way the light oils, as they are called, are separated from the heavy oils, which remain in the still.

The next step is to take the oils driven off by distillation and mix them with sulphuric acid, and give the mixture a thorough stirring so as to bring the acid in contact with every particle of oil. This causes the impurities that passed off in the distillation to settle at the bottom of the tank. The oil is then washed with a solution of soda, ammonia or

lime to remove any acid that may remain. The oil from some of the wells contains sulphur, and when this is present it must be removed by still another process.

By the distillation of crude petroleum we get rhigolene, naphtha, gasoline, benzine and kerosene. There is left in the still a heavy, dark fluid from which lubricating oil and coal-tar are obtained. From this coal-tar we get the same products that we do from that of the gas tanks.

Kerosene is the most important article obtained from petroleum, and a great deal of study has been given to improving its quality and making it safe. When people first began to use kerosene in lamps, serious accidents often occurred from explosions. These explosions were caused by the gases that arose when the flame of the lamp heated the oil. To be perfectly safe, kerosene must be free from naphtha and gasoline, so it is again distilled at a low temperature after the impurities have been removed.

A good quality of kerosene should not give off any inflammable vapor at the temperature of 100 degrees of our ordinary thermometer, and should not ignite below 125 degrees. If we wish to test kerosene, all we have to do is to mix a small quantity with water, place a thermometer in the dish and place the mixture over the fire. When the

thermometer indicates 105 degrees, we apply a lighted match to the surface of the water. It we get a flash of flame, the kerosene is not safe and should be set aside.

USES OF PETROLEUM.

PETROLEUM was first used in this country for medicine, as we have already seen. Besides the liniment there mentioned, we now have cosmoline, and vaseline, or petroleum ointment, with which we are all familiar. This compound is made from the refuse of the still. Rhigolene is sometimes used by surgeons to prevent pain during an operation. It is also used in making freezing mixtures, as its rapid evaporation at a low temperature causes it to produce cold.

Besides the aniline dyes and lubricating oil obtained from the refuse of the still, we also get paraffine, which is used for candles and for chewing gum. Just remember the next time you have a good chew of gum in your mouth that you are chewing petroleum wax flavored with a little extract of wintergreen or pepermint, and see if you think the pleasure is worth the effort.

Naphtha is used extensively in the manufacture of varnish, and a product of the California wells is valuable for paints and for coating paper. Gasoline is more familiar to us, as we know of its use in our gasoline stove, but we may not think that it is used for gas to light many homes and large buildings. This gas is made by forcing a current of air through the gasoline so as to evaporate it rapidly. It burns nearly as well as the gas made from coal. Common illuminating gas is made from crude petroleum by letting it drip upon red-hot coke. Crude petroleum is also used for fuel in furnaces and engines in those places where other kinds of fuel are too expensive. From this we see that by far the most important uses of the petroleum products are for illuminating and heating purposes.

Before the discovery of this use of petroleum, candles and oil lamps were the only means people had for lighting their houses. They gave but lit-

tle light, and were expensive. But very few families could afford sufficient light to enable one to read during the evening. The oil used in the lamps was obtained from the Greenland whale, and these animals had been hunted to such an extent that but very few could be found. Whale ships would often have to spend two or three years in the northern seas before they could get a cargo of oil, and people were beginning to wonder what they would do for lights.

A short time before this discovery of petroleum, companies had begun the manufacture of an oil by distilling cannel coal or pitch. This oil was better than anything before used, and was sold under the name of coal-oil or rosin-oil. It was about the color of crude petroleum and had as disagreeable an odor. It formed a gum on the wick which gave a good deal of trouble, and was not extensively used. With the introduction of kerosene all this was changed. Now illuminating oil is so cheap that everyone can have all the light necessary to make home as cheerful by night as by day.

The discovery of the oil fields and the petroleum products was one of the greatest blessings ever given to the country. The influence of these products upon the world has been scarcely less than that of the steam engine or electricity, and all this has been brought about by the energy and ingenu-

ity of a few men in the United States. A prophet of the olden time said, "To them that sit in darkness a light shall spring up; darkness shall be as noonday, and at evening time it shall be light." These great discoveries have made his words literally true.

SUGGESTIONS: Find on the map in your geography the countries and states where petroleum occurs.

Give an account of the discovery of petroleum in the United States.

What is the theory for the formation of petroleum? What proofs have we that this theory is correct?

See how many different kinds of burners you can find on kerosene lamps, and give a description of each.

How is oil brought to your town?

Find all the facts you can about petroleum, and write a full description of the industry.

NATURAL GAS.

NATURAL gas is another substance found in the earth in connection with petroleum. While the gas fields are always within the limits of the coal fields, gas is not found in all those places where coal or petroleum exist, and it may be found independent of either of them. The most important gas fields are in western Pennsylvania, southern Ohio, and southern Indiana. The Ohio and Indiana fields are the most productive.

Natural gas has been known and used for a very long time. The Chinese have burned it for many years, taking it from wells in bamboo pipes and

using clay burners. And the Persians, who were the ancient fire worshipers, kept it burning day and night in connection with their worship. Perhaps this inflammable gas, issuing from the earth, influenced them to a large extent to worship a god of fire.

The gas was first discovered in the United States in connection with the salt wells in the Kanawha valley, in Virginia, in 1807. It was first put to practical use in 1821, in Fredonia, New York, when the inhabitants began to light the village with it. The gas was first conveyed from the well in a wooden pipe. Burners were made by boring holes the size of a small knitting needle in the pipe. These gave a light about equal to that of two candles. Lead pipe soon took the place of wood, and in a short time the gas came into general use in the village.

About twenty years after the introduction of natural gas into Fredonia, the salt manufacturers of the Kanawha valley began to use it to evaporate the brine from their wells, and found it very good fuel for the purpose. In 1875 an iron manufactory near Sharpsburg, Pa., began to use it in its furnaces. They obtained such good results that other firms soon adopted it. In this way natural gas came to take the place of coal for fuel.

The greatest advancement in the use of natural gas was made, however, when the city of Pittsburg

decided to adopt it for all heating and lighting purposes. The substitution of gas for coal in the furnaces of all the great iron and glass manufac-

turies of Pittsburg was an important event in the history of that city. Before this, Pittsburg was the smokiest and dirtiest of cities. Now the air is

clear, and the streets and buildings clean because they are free from soot.

Natural gas burns without smoke, odor, or ashes, and with great heat. These qualities make it one of the best fuels to be found. It is excellent for warming houses as it can be used either in grates or stoves. In the localities where it occurs, the climate is so warm that stoves are not needed, and the grate is much more cheerful. The gas pipe comes up under the hearth, and logs resembling those of the old fashioned fire-place and made of fire clay are placed on the andirons. The gas burns around these logs and the heat from them warms the room. A similar plan is followed in the furnaces of engines, except that coarse fire brick take the place of the logs. In iron furnaces the gas is mixed with a strong current of air that intensifies the heat so as to melt the iron.

Natural gas does not give as good light as the common illuminating gas made from coal. However, when mixed with a certain proportion of air it does very well, and is so cheap that those using it can have as many jets as may be needed.

From what we have said of this gas in connection with petroleum, we know that it is found wherever petroleum exists, and sometimes must be allowed to escape before the oil can be obtained. But it has been found in large quantities in rock that does

not contain oil, and in those regions men find it very profitable to bore for gas alone.

Gas wells are sunk and piped in much the same manner as oil wells. As most of the wells are some distance from the towns where the gas is used it is conveyed to them in pipe lines the same as petroleum, only it does not require as much pumping to force it along. When a new well is sunk, the pressure is usually very great, being from four to five hundred pounds to the square inch. This is nearly three times the pressure in the boilers of locomotives used on the fastest express trains. In one instance the pressure was eight hundred pounds to the square inch. This pressure forces the gas through the pipes at a rapid rate, and for a long distance. In the first pipe line opened, the gas traveled seventeen miles in twenty minutes. Some of the pipe lines are quite long, like that from Kokomo, Indiana, to Chicago, and in cold weather when a great deal of gas is used, pumps have to be employed, but at other times the pressure is sufficient to furnish a good supply.

When natural gas was first discovered it was considered worthless, and the amount allowed to run to waste is beyond measure. It is estimated that the amount of gas flowing daily from the first well in the Marysville district was equal in value to one thousand tons of coal; and this well was

allowed to flow for five years before the real worth of its product was understood. Now the gas is carefully stored, and all possible care taken to prevent waste.

There are two methods of storage; one by boring the well almost down to the gas and holding it until the gas is needed, the other by piping and packing the well as soon as it is bored. When the last method is employed, a valve is placed on the pipe at the mouth of the well. This valve is regulated by a screw, and in turn regulates the pressure in the pipe conveying the gas to the consumers.

We can think of coal, petroleum, and natural gas as stored up sunlight of the past ages. This is because all life and growth depend upon the sun's rays; without them the poisonous gases in the air would not have been changed to the vegetable matter from which coal was made, neither could the animals have lived in the sea. The great power of the sun also had much to do with bringing about those changes that have made the earth such a beautiful home for us. How wonderful that God stored up these useful substances for us so many ages before man lived upon the earth.

IRON.

THE FIRST BLACKSMITHS.

A BLACKSMITH shop is one of the most interesting places a boy can ever visit. The puffing bellows, the roaring fire, the flying sparks, and the strong man in a leather apron, who hammers the white-hot iron into any shape desired on his ringing anvil, are all objects of wonder when seen for the first time. Well, the smith and his trade are worthy our wonder and our study, for iron is the most useful and valuable of all metals.

Is a piece of iron worth as much as a piece of gold or silver of the same size? surely not, but the iron can be used for so many more purposes than either of these metals that we have more comforts and conveniences from it than from both of them together. The real value of a thing depends upon its usefulness, and this is why iron is so valuable, and why we find so many articles made of it.

Iron has been the metal of civilization; its use has marked the progress of all nations in the arts and sciences, and we can easily determine the position of any nation by the extent to which it uses iron. We first read about this metal in the Old Testament. If we look in the book of Genesis, in the fourth chapter, we read that Tubal-cain was the instructor of every artificer in brass and iron. The Egyptians used iron in the great pyramids, and it has been found in the ruins of Ancient Babylon. The Persians of old and the smiths of Damascus were famous for their weapons and edged tools. The Damascus swords have been known for their keenness and temper the world over. There has been scarcely a nation that has pretended to be civilized that has not used iron to some extent, and to-day it enters so largely into our life that we could not do without it.

> "Since the birth of time throughout all ages and nations,
> Has the craft of the smith been held in repute by the people."

ORES AND MINES.

Iron is not found pure, but in combination with other substances in the form of rock, called ore. Iron ore is pretty generally distributed over the earth, but is usually found in the greatest abundance in mountainous districts. In the United States it is found all along the Appalachian Mountain System, around Lake Superior, in Pilot Knob and Iron Mountain, Missouri, and to some extent in Ohio and Illinois. The presence of iron in any rock is easily told because it forms rust when it comes in contact with water, and this turns the surface of the rock a dirty red color. The same color is also often noticed in the bottom of streams flowing through an iron region.

The most common ores are red hematite, brown hematite, magnétite, carbonate, and spiegeleisen (spiē-gel-ī-sen), a compound of iron, carbon, and maganese. The red hematite is by far the most abundant and furnishes more than half of all the ore mined. Of the remaining portion, about three-eighths are magnetite, one-sixth brown hematite, and the remainder carbonate and spiegeleisen.

The principal iron mines of the United States are located in New York, Pennsylvania, Alabama, Tennessee, Virginia, Wisconsin, Michigan and Minnesota. Minnesota produces the most, and

Michigan and Alabama rank next, with about an equal amount each. Magnetite is found in largest quantities in New York, and carbonate in Pennsylvania and Ohio.

Hematite, often called speculer ore, is a compound of iron and oxygen, and is what a chemist would call an oxide of iron. It varies in color from a gray to a brownish red, and its different names are due to its color. It is a coarse, rough rock, and, to one unaquainted with its composition, would be considered wholly worthless. Extensive beds of it occur around Lake Superior and in Missouri.

Magnetite, or magnetic ore, is another compound of iron and oxygen, but it contains a larger proportion of oxygen than the hematite. It is of an iron black color, and is found in beds and also in separate crystals. This is one of the most interesting of minerals as it is magnetic, and it is from this ore that natural magnets are obtained. When a piece of this ore that is strongly magnetic is placed in a box of iron fillings, they will stick to it so tightly that it is quite difficult to clean them off. Most of the natural magnets are found in Siberia and the Island of Elba, but they occur in small quantities on an island off the coast of Maine, in Rhode Island, and in Arkansas.

The carbonate is a compound of iron and carbon dioxide, and is of a grayish color, varying to brownish-red. It is crystalline in structure, and is called spathic iron, as the crystals resemble spears. Carbonate is an excellent ore, and is mined much more extensively in England than in the United States.

The methods of mining iron ore depend upon the character of the ore and where it is found. If in the form of a ledge, it is blasted out like any ordinary rock. If it occurs in the form of sand or gravel, it is scooped up by immense steam shovels and placed directly on the cars for transportation. About the only thing of interest around an iron mine is the machinery for removing the ore. Wherever it can be arranged, a railway is constructed on such a plan as will cause the loaded cars to run down an incline and draw the empty cars up. In a hilly country this is usually quite easy to accomplish. In places where the mines sink deep into the earth, about the same methods of working are used as we find in a coal mine. Everything about a mine of hematite is the color of the ore, as the rock is soft and forms a fine dust which sticks to all objects it touches. The miners working on red hematite have the complexion of Indians; but the dust washes off readily, so, like some boys and girls, the miners may have their

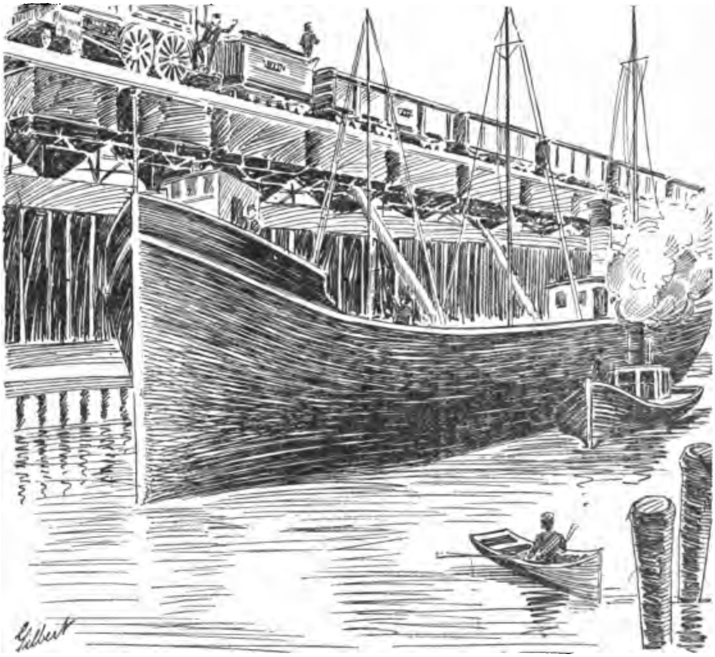
complexion greatly changed by the use of a little soap and water.

TRANSPORTATION.

Much of the ore is taken a long distance from the mine before it is smelted. This is because many mines are situated a long way from the coal fields, and also because mixing certain ores tends to make them smelt more readily and produce a better quality of iron. The ore is so heavy that the expense of handling is very great, and the mining companies are obliged to keep this expense as low as possible. We may take pride in knowing that the devices for moving ore in the United States are better than those in any other country, and that more ore is transported over long distances.

Special ore cars are constructed. These are built on one of two plans; so the bottom can drop and let the ore out, or so the car can be easily tipped on one side and dumped. The ore docks are on the same plan as coal docks found on wharves. They are from forty to fifty feet high, and are reached by a long incline, so that a train of loaded cars can be run upon them without difficulty. Under the tracks are storage bins, called

pockets. When the train is in place, all that is necessary to unload the cars is to open the trap doors in the bottom, or dump the car. The shipping docks of the Lake region are the largest in the world,



ORE DOCK.

and altogether have a length of nearly five miles. Shutes lead from the pockets to the boats, and opening the shutes is the only labor necessary to load the boats; the ore slides out of its own weight. In this way boats can be loaded very

rapidly. Steamers are constructed for the special purpose of transporting ore, and have a capacity of from five thousand to eight thousand long tons (2240 pounds). Such are the facilities for handling ore that a steamer can be loaded in from three to five hours.

It is so much cheaper to freight the ore by boat than by rail that as much as possible is shipped during the season of navigation. The boats can go down the lakes loaded with ore, and return with coal, so they are sure of freight each way without the inconvenience of planning for an entirely different kind of a cargo. The facilities for unloading the boats at the ports on the lower lakes are as well adapted to this purpose as those in the mining region are for loading. The ore is piled up on the docks to await shipment, and the piles look like small mountains. All ore to be used at once is unloaded directly on to the cars; but the boats can bring during the season much more than the railways can remove, so some is left on the docks for transportation during the winter.

There are numerous devices for unloading the ore, but all are on the plan of a bucket fastened to a movable crane, or an endless belt, like that used in a grain elevator. The unloading is quite rapid, but takes more time than loading directly from the shutes.

HISTORY.

Iron was probably unknown to the Indians when this country was discovered. At least, they made no use of it if they knew of its existence. Tools and weapons made of copper have been found in abundance in their ancient dwellings, but nothing of iron. Neither did the Spaniards find anything made of iron among the Astecs or Incas, and they were much further advanced in civilization than any other Indian nations.

Iron was first discovered in America in North Carolina by some of the early French explorers. In 1608, a ship belonging to the London Company sailed from Jamestown loaded with iron ore and several other commodities. Iron was first produced in Virginia, but the Indians destroyed the works the same year that the Pilgrims landed at Plymouth.

The first iron works in the United States were built at Lynn, Mass., and were in successful operation in 1645. Governor Winthrop was one of the prime movers in the enterprise, and the work continued for about forty years. The proprietors obtained several privileges from the colony, among which was one allowing them to sell the iron for twenty pounds (nearly a hundred dollars) a ton, but the works never paid, and when

the difficulties with England caused that country to forbid the manufacture of iron in the colonies, they were abandoned.

This plant consisted of a blast furnace, or foundry, and a refining forge, and they supplied the inhabitants of the locality with all their iron tools and household implements as long as they were in operation. The ore used was called bog ore, and was a variety of brown hematite found in the bottom of ponds and in swamps in the form of loose rocks. The first piece of hollow ware made in America was cast in these works in 1645; it was a small pot having the capacity of about one quart.

Although these works were abandoned, during the French and Indian war several iron factories were in operation, and cast cannon, shot, and bullets as they were needed for the colonial troops. At the close of the Revolution, iron works were established at several places in New York, Pennsylvania and New England. As the demand for iron increased, factories have multiplied, and at present millions of tons of iron and steel are produced in the country each year.

SMELTING.

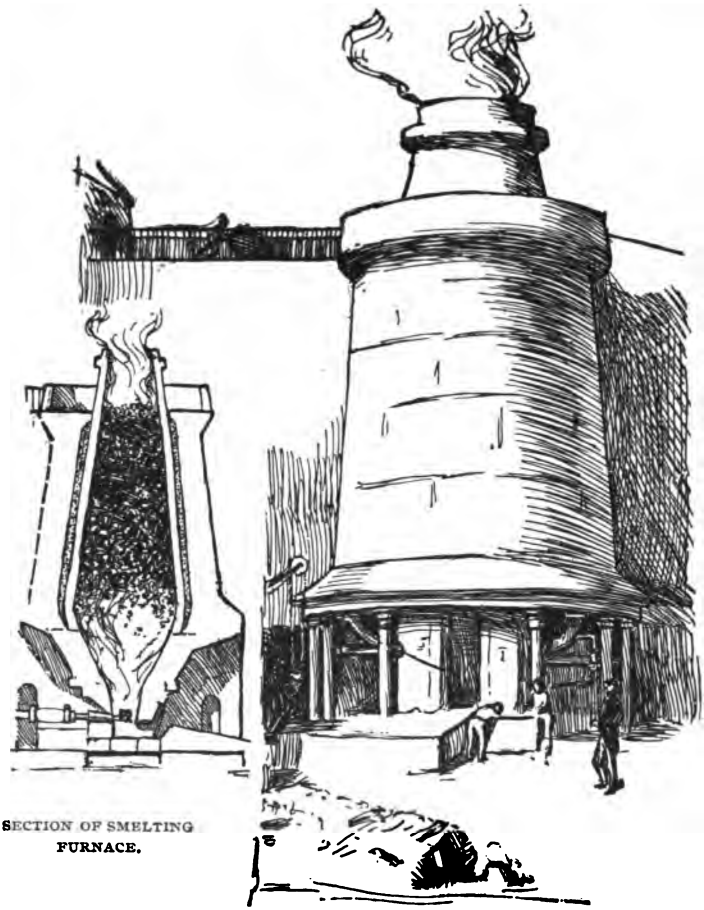
The substances mixed with iron in its ores are oxygen, silicon, carbon, sulphur and phosphorus.

These are not all found in the same ore, but two or three of them are frequently mixed in one compound, and they must be separated from the iron before it is fit for use, and this process of separation is called smelting. The simplest arrangement for this purpose is the blacksmith's forge. If we place small pieces of ore in the fire of the forge, and cover them with coal, and then force the fire to an intense heat with the bellows, the iron will melt and run down to the bottom of the fire. It can then be taken out and hammered into any shape desired.

The ancient smiths did not have any forge, their anvil was a stone, and in all probability their first hammers were stones tied to a stick for a handle. Undoubtedly they had much trouble in smelting the ore and shaping the iron. They used to place their fires in such places in the rocks as would cause a strong current of air to pass through them when the wind was in a certain direction, and made iron when the wind blew, as farmers now-a-days make hay when the sun shines.

The first improvement on this rude arrangement was the construction of walls so placed as to inclose a V-shaped space. The opening of the V was towards the point from which the wind was most liable to blow, and the fire was made just beyond the narrow space between the walls. By this ar-

rangement a strong draft was created with a light



SECTION OF SMELTING FURNACE.

SMELTING FURNACE.

wind. The Persians improved upon this by inclosing the ore in a rude furnace, which was noth-

ing more than a stone wall around successive layers of charcoal and ore. Rude as this structure was, it was a great step in advance, and enabled the iron workers to produce much more iron than they had ever before been able to do.

The smelting furnaces now in use are the result of successive improvements on the rude device of the Persians. They are devices for the purpose of bringing a strong current of air in contact with the fuel and ore, so that an intense heat may be brought to bear on the ore and smelt it.

The first blast furnaces erected in the United States were patterned after those in England, and were about fifteen feet square and thirty feet high. The outside wall was made of any sort of rough stone, and was several feet thick. The lining was of sandstone, as this would withstand the heat. There was usually an opening at the bottom on each of the four sides. The fuel was charcoal, and the furnace was fed at the top, as at present.

From these primitive structures of our forefathers, we come to the modern blast furnace shown in the cut. Iron hoops have taken the place of the thick stone wall, and fire-brick that of the sandstone. The structure is about eighty feet high. The top, or mouth, is in the shape of an inverted cone, and is kept closed by a conical-shaped damper which weighs several hundred pounds. When it

is necessary to refill the furnace, this damper is raised by machinery. We notice that the interior narrows towards the base where the pipes conveying the blast enter. Beneath this point is a tank-like structure, called the hearth. As the iron melts it runs down to the hearth whence it is drawn off.

There has been as much improvement in the blast as in the construction of the furnace. The blowing apparatus of the old furnace consisted of wooden boxes into which were fitted pistons that were worked by a rude water wheel. Only a limited amount of air could be supplied by this arrangement, and the pressure never exceeded two pounds to the square inch. Now large air pumps driven by powerful steam engines force an unlimited supply of air through the fire, at a pressure of eight or nine pounds. Besides this, the air is heated to a temperature of 1,100 or 1,200 degrees before it enters the fire, and this very greatly increases the smelting power of the furnace.

The stoves in which the air is heated are a very important attachment to a furnace. They are huge cylinders, often larger than the furnace, and divided by partitions into several chambers. The air passes from one chamber to another over these hot partitions, until it has been through all the chambers before it is admitted to the fire. There

are usually three or four stoves to each furnace. The air is heated by burning the gas that comes from the fuel used in smelting the ore, thus saving a good amount of fuel.

A space is left between the outer and inner wall around the hearth, and this is kept filled with running water to keep the intense heat from destroying the lining. The pipes conveying the air to the fire are also kept cool in the same manner.

Now we have seen something of the construction of a smelting furnace, let us try to understand how it works. If we could only get a glimpse down into this combination of volcano and tornado, we should be able to understand how iron is smelted much better than we can by any mere description. But this is impossible, for no one could withstand the heat or the poisonous gases that arise when the damper is lifted. When the furnace is all ready to be charged, it is filled with fuel, ore, and limestone. The fuel is usually coke, and the ore and limestone are crushed into small pieces; the finer they are the faster the furnace works. The fire is now lighted and the blast applied. The process of smelting has begun and will be kept up until the furnace wears out, or some needed repairs have to be made. This may be for months, or even years. The roar of the blast as it passes through

the stoves and into the fire is almost deafening to one not accustomed to it.

When this stew of limestone and ore has been cooking for about twelve hours, the iron has been

SOW AND PIGS.

extracted and is ready to be drawn off. Surely no vessel will hold this fiery liquid for any length of time, so some other provision must be made for it. We notice around the base of the furnace a bed of sand which has been regularly laid out in channels and cross channels, and into this the iron is

allowed to run. The channel leading from the furnace to the shorter ones is called the sow, and the others are called pigs. From these the iron takes the name of pig iron. A bar of pig iron is about forty inches long, and from three and a half to four inches square.

The casting of pig iron is a sight well worth witnessing. When the "cast" is ready the blast is shut off, the workmen tending the furnace loosen the mass of clay and coal dust which closes the opening to the hearth, and a shower of sparks rushes out followed by the stream of molten iron, which is at a white heat. Workmen stand along the channels to urge the iron along that it may reach the farthest pig before it gets cool enough to begin to thicken. Soon all the pigs are filled and the bed of sand has been transformed into a boiling and seething volcano. As soon as the iron cools, the men break the pigs from the sow and then break the sow up into pieces of suitable length to handle.

You have probably asked by this time why the limestone is put into the furnace. The ore contains silicon and other substances that will unite with the limestone under a high temperature, and by using it much more iron can be obtained and that in a much purer state. The substance formed in this way is called cinder or slag. It runs to the

hearth and floats on top of the melted iron. It can be drawn off before the iron, or may be drawn from a separate opening at the same time. Most cinder when cooled resembles a coarse rock of dirty brown color, and is worthless except for purposes of filling up holes in roads and irregular surfaces around the works. But that from some ores resembles glass, and is valued for making vases and other ornaments. It usually has a variety of colors, and the objects made from it are very pretty.

After the first "cast" has been drawn, the others follow at intervals of about four hours, and the furnace is constantly charged from the top. Great care is exercised in charging to get the right proportions of each substance. Every barrow load of ore, coke, and limestone is weighed, so no waste will occur. These loads are then dumped into the space between the damper and the sides of the furnace, and when the damper is raised they fall into the space below. A furnace of average size will make about 175 tons of pig iron in a day.

WROUGHT IRON.

While smelting the ore removes a large quantity of the impurities from the iron, still pig iron contains so much sulphur, phosphorus, carbon, and silicon that it is unfit for most purposes until the

greater portion of them has been removed. The iron obtained from removing these impurities from

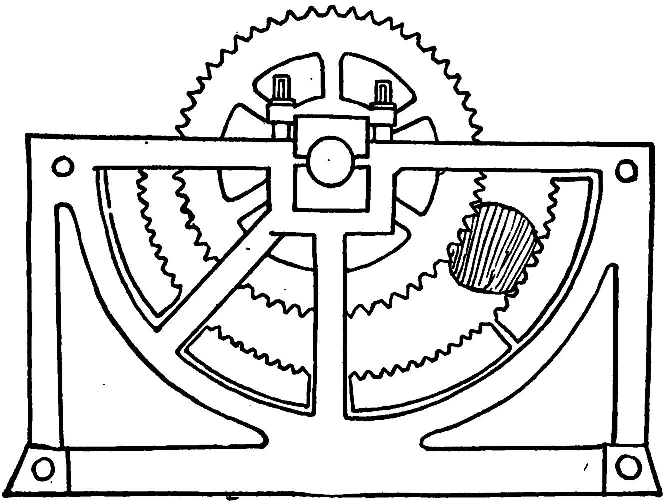
PUDDLING FURNACE.—REMOVING THE BALL.

pig iron is known as wrought, or malleable iron, and is placed on the market in the form of plates, bars, and rods.

Wrought iron is made by breaking pig iron into chunks and placing them in a puddling furnace. This is altogether different from a smelting furnace. Its length is greater than its height; it has a sand or iron floor, and a vaulted roof. The fire is placed at one end and the flue at the other. As the flame passes under the roof it is thrown down upon the iron and heats it. A quantity of iron rich in oxygen or magnetic ore, is placed on the floor of the furnace, and as the chunks of pig iron become soft the oxygen from this unites with the impurities and forms cinder.

Puddling is a difficult task, and requires great skill on the part of the workman. As the pieces begin to soften, the puddler stirs them vigorously with a long iron rod inserted through a hole in the door of the furnace. He does this to bring all parts of the iron in contact with the hearth and the air, so the impurities may be acted upon. He watches the changing color of his iron very closely, and when little globules of pure iron begin to appear, he says it is "coming to nature", and it is ready to be removed. He now makes the pieces up into balls of 60 or 80 pounds weight and signals his assistant; the door of the furnace is opened, and the mass of iron seized by long tongs and hurried off to the squeezer.

The impurities are still in the iron in the form of cinder, and must be expelled before it cools. Formerly this was done by placing the balls under a heavy hammer and pounding the cinder out. Now it is more frequently done by means of a machine called the squeezer. As you will see



SQUEEZER.

by the cut, this is a machine by which the iron is rolled into a cylinder, and at the same time continually forced into a smaller space.

When the cinder has been removed, the iron is placed between rolls and worked into bars. These bars are then cut up and reheated and rolled again. Within certain limits, the more

times this is done the better the quality of iron produced, as each heating drives out some cinder. The final rolling leaves the iron in the form desired for market. The rolls are so constructed as to make the bar any shape desired.

We have said that puddling required great skill, and possibly this needs a word of explanation, for it certainly does not require unusual skill to stir the melting mass. The skill is necessary to enable the puddler to tell just when to remove the ball from the furnace, and he must do this by noticing the color of the iron as he works it. A moment too soon or too late and the entire lot is spoiled. We must not think from the rough appearance and coarse garb of these men who work in iron mills that they are uneducated or unskillful, for their knowledge of their trade is extensive, and their skill is of a high order.

STEEL.

It is not an easy matter to tell just what steel is. We may say for all general purposes that it is a compound of iron with a certain proportion of carbon and silicon, that places it between cast iron and wrought iron.

There are several processes for making steel, but only two need our attention. One of these is

burning carbon into wrought iron; and the other burning it out of cast iron. The first process is the oldest and simplest and has been practiced for centuries. Bars of wrought iron are placed in powdered charcoal in a fire-proof box and subjected to a furnace heat for several days. During this time the bars are kept at a red heat, and when taken from the box they are covered with blisters. Steel made in this way is sometimes called blistered steel. These bars are then cut up, re-heated, and welded together, or melted in crucibles and cast into ingots. This is necessary to make the metal of uniform quality, as there is more carbon on the surface of the bars than in the center.

The process of making steel now in most general use is that of burning the carbon and silicon out of cast iron. It is called the Bessemer process from its inventor, Sir Henry Bessemer, of England. This is one of the most important discoveries ever made in connection with the working of iron, and has completely changed the methods of working, and made it possible to use iron for hundreds of purposes that it was not suitable for before.

In order to understand the Bessemer process of steel making, we must give a little attention to the chemistry of air. You have probably learned

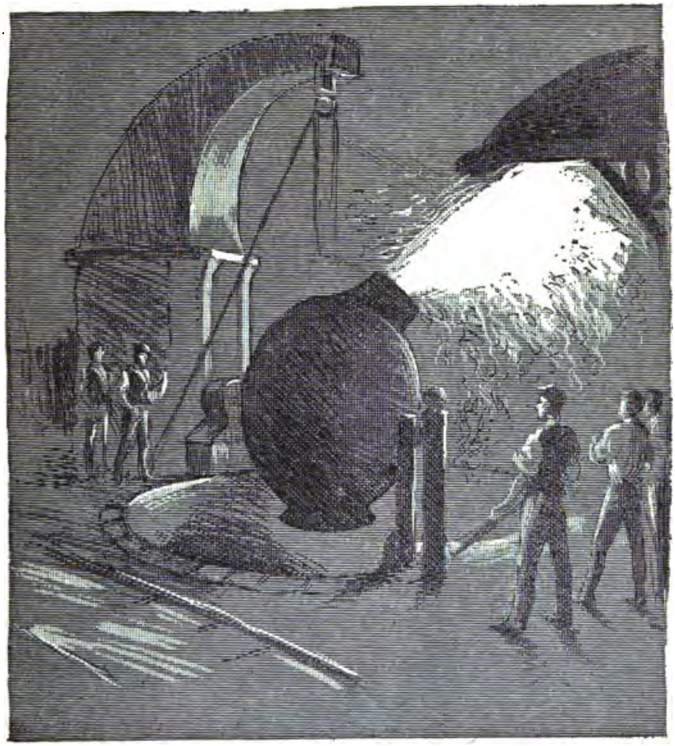
that oxygen and nitrogen are the two gases found in the air in largest quantities. Now oxygen is the gas which causes all the changes produced by the air. It causes fruit and vegetables to decay, and fires to burn; it is also the life-giving property, for when we breathe it is the oxygen that purifies the blood. The union of oxygen with any substance is called oxidation, and the product formed is an oxide.

Mr. Bessemer thought that if a current of air could be driven through melted cast iron, the oxygen would unite with the carbon and silicon and oxidize them, or, as we would say, burn them out. By experimenting he proved that his theory was correct.

Bessemer steel is made in a pear-shaped vessel called a converter. Its greatest diameter is eight feet, and its height fifteen feet. It is lined with fire-proof clay, and has from seven to twelve holes in the bottom through which the air is forced. The converter is placed on pivots so it can be tipped from a vertical to a horizontal position.

When the mass of molten iron has been run into the converter a current of air, as strong as can be produced by engines of four or five thousand horse-power, is turned on. Now a strange sight may be witnessed by any one present. The air expands as it is forced up through the metal,

often throwing large masses of it above the mouth of the converter only to have them fall back into the boiling mass. The oxygen of the air



BESSEMER CONVERTER.

attacks the silicon first and burns that out. Little or no flame is seen while this is burning, but sparks escape from the converter. When the

silicon has been removed it floats on the top of the iron as slag. The next step is the burning of the carbon, which does not begin, strange as it may seem, until the silicon has been burned. When the oxygen attacks the carbon a brilliant flame issues from the mouth of the converter with a roaring that is terrific. This flame continues as long as there is any carbon to burn, and when it ceases the steel maker knows that the blast must be shut off. The iron in the converter is now free from carbon and silicon, and if poured out would be worthless. The necessary proportions of these substances are now placed in the converter in the form of spigeleisen, which is rich in carbon and manganese. Another violent action follows, and the iron has been converted into steel, which is poured out and cast into ingots.

By varying the amount of carbon placed in the converter, steel of any quality can be produced, and little distinction is now made between steel and malleable iron, as much of the iron manufactured by this process is as soft as the best wrought iron. The time required to convert a mass of iron varies somewhat on account of the quality of the metal and the power of the blast, but is usually fifteen or twenty minutes. The advantages of the Bessemer process over the old method are, that a definite amount of carbon can be combined with the

iron, and a metal of uniform quality can be made.

A Bessemer steel plant, when the converters are in full operation, is a weird sight,—one more dazzling than the most brilliant fireworks ever invented.

TOOLS AND MACHINERY.

In no industry has there been more study and invention than in the working of iron. We saw that the first iron works were very simple, and the hammer was probably the first tool invented by man. It was certainly the first tool he used in working iron, and it was undoubtedly very imperfect. We have seen how one change followed another in the invention of the smelting furnace, now let us notice some of the machines for working the iron.

At first, all the cinder had to be expelled by hammering the soft mass of iron on an anvil. The hammer was gradually perfected until the smith had the heavy sledge, and the quality of the iron made in this way was excellent. But it was a slow and fatiguing task, and the strongest and most skillful smith could produce only a small quantity in a day.

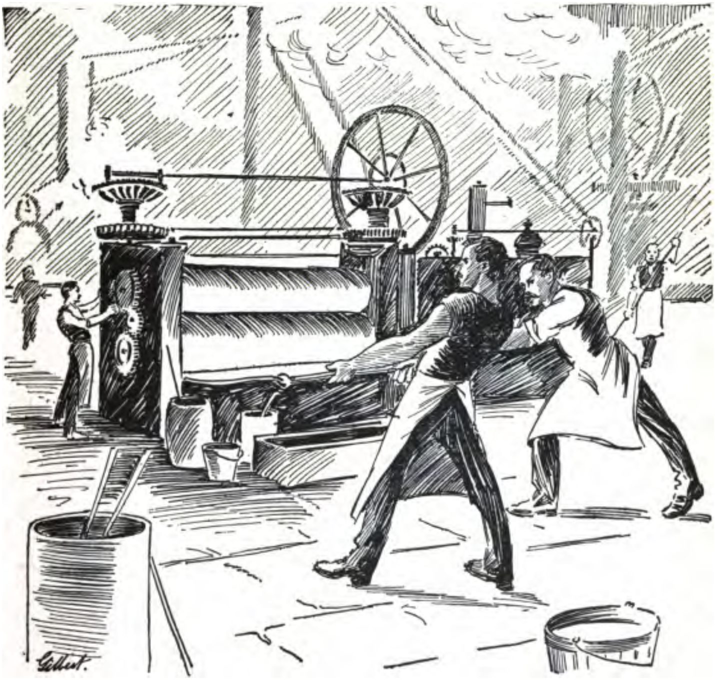
In the course of time the tilt hammer took the place of the sledge. This hammer is made by

taking a heavy beam and hanging it on a pivot so placed as to divide the beam into two arms of unequal length. The longer arm is about twice the length of the other. The hammer head is fastened to the end of the longer arm, and the end of the shorter is pressed down by the cams on a revolving axle. As the cam slips off the end of the beam it falls, and by its own weight strikes a heavy blow. The tilt hammer can be made to strike very rapidly, and does excellent service.

But the steam hammer now in use is even a greater improvement over the tilt hammer than that was over the sledge. This hammer was invented by Mr. James Nasmyth, of England, and is named for him. It is worked directly by steam power, the same as an engine. It can be constructed of any size desired, and is so perfectly adjusted that it will strike a blow so delicate as to drive a pin into wood without bending it, or so powerful as to forge the shaft of the largest ocean steamship. If any of you visited the Krupp Gun Works at the Columbian Exposition, you probably saw the shafts forged by some of their great hammers. The head of one of these hammers is twelve feet long, five and half feet wide and four feet thick, weighs fifty tons, and has a stroke of nine feet. The foundation for this machine is one hundred feet deep, and consists

of stone, wood and iron, cemented and bolted together.

Slitting machines and rolls were among the early inventions that were of great value to the



ROLLING MACHINE.

iron workers. By them the iron is worked into bars and plates of almost any size and shape. Some of these rolls turn out plates more than a foot thick, to be used in covering the sides of iron-

clad ships, while others make sheets as thin as tissue paper. Still others shape the rails for our railways, and others make the different forms of bar iron of commerce.

The shears is also another important machine of the iron mills. This is an arrangement by which two plates of steel with sharp edges may be made to shut past each other. One blade is stationary, and the other is attached to a movable frame, and works up and down with a slow motion. The machinery operating this frame is very powerful, and a machine of average size will cut a bar of steel as large as a man's wrist as easily as we can cut a piece of string. If we attempt to pick up the piece cut off, we do so at the peril of burnt fingers, for the pressure on the bar is so great that it becomes quite hot. In some of these machines we find steel punches taking the place of one blade, and a flat, table-like arrangement with holes in it taking the place of the other. This is a piercing machine, and is used to punch holes in the plates. This saves much time and labor formerly used in drilling.

PROPERTIES AND USES.

Iron is seven and one-half times heavier than water, and a cubic foot of it weighs about 470

pounds. When pure, it is of a silvery white color and takes a high polish. The bluish-black appearance of bars and castings is due to an oxide formed when the red-hot iron comes in contact with the air. When this is filed off, we see the color of the real metal.

Wrought iron has a fibrous, and cast iron a somewhat crystalline structure. Cast iron is very hard and brittle, but will withstand great pressure. Wrought iron is soft and easily bent, but will sustain great weight. It is estimated that iron wire will sustain a weight of a mile of itself. On account of the different characteristics of cast and wrought iron, engineers have to be very particular which kind is selected for different purposes. A mistake in the material might lead to serious accidents.

CAST IRON.

We have already noticed that malleable iron can be rolled into thin sheets; it can also be drawn into wire finer than thread, so fine that 150 pieces laid side by side will not cover a space an inch wide. A strange thing about this is that the finer the wire is made, the stronger

WROUGHT IRON

it becomes. All the wire cables are made by twisting fine wire together. The great suspension bridges at Brooklyn and Niagara are supported by immense cables made of wire no larger than ordinary wrapping twine.

When melted iron cools, the particles tend to arrange themselves in the form of crystals. This causes the mass to expand a trifle just before it becomes solid. This peculiarity makes iron the most suitable of all metals for castings, as it fills every little niche and crevice of the mould and perfectly reproduces the pattern. Many of the ornaments on castings are curious and interesting. Even the delicate structure of lace and the texture of leaves can be perfectly reproduced in the hard iron. Cast iron articles are so common that we should have to think for a long time before we could write out a list of all we have seen. We find them in the shop, on the farm, in the store, and especially in the home, where they contribute much to our convenience and comfort.

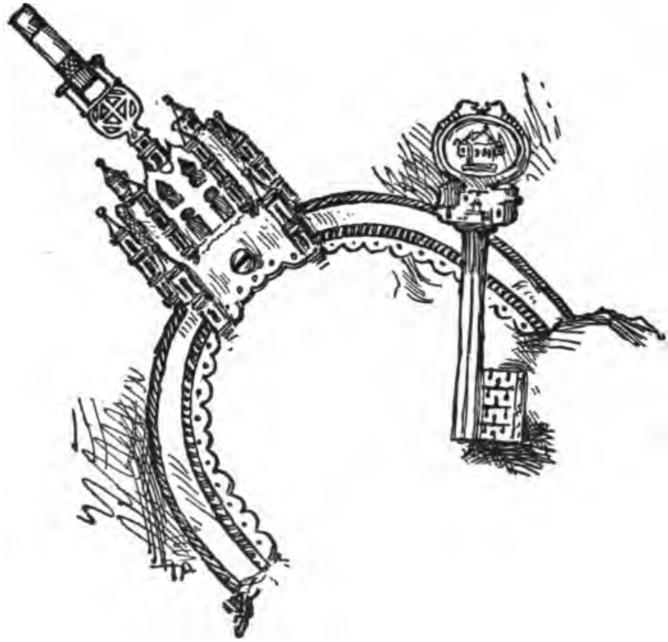
The use of wrought iron is equally extensive. It enters into all machinery, forms the trusses to bridges and the frame work to all large buildings, and from it are made the nails, bolts, and screws used to fasten these same buildings together. In the form of steel, it constitutes the rails over which we ride, and the greater part of the engine that

draws the train. Besides these larger structures, there are thousands of smaller implements made of malleable iron and steel.

The elastic power of steel makes it of use in the construction of springs. We find steel springs in our carriages and cars to protect us from the jar of the wheels; we find them in our clocks and watches to keep them running; in traps to catch the rats and mice about the house, and the wild animals in the woods; and in our couches and beds to make them soft and comfortable.

A steel chisel can be made so hard that it will cut another piece of steel, or so soft that the edge will be dulled by driving it into a piece of hard wood. This peculiarity of steel enables the machinest to make tools just suited to all sorts of work. Determining the degree of hardness is called tempering the metal, and is done by various methods of heating and cooling. If steel be heated white-hot and thrown into ice-cold water, it becomes as hard as it can be made. But if left to cool very slowly, it becomes as soft as possible. Between these extremes all degrees of hardness may be obtained. Each kind of tool has a temper of its own, and which makes it the most useful. Most of our common tools, like knives, chisels and saws, are tempered before they are polished; but sometimes the workman polishes them first. When

this is done, the tool has a beautiful bluish color, caused by the oxide like that found on the surface of bars of wrought iron. Sometimes we see letters and other designs in gray traced on the blades of



CLASP AND KEY.

razors and knives. These are made by covering the blade with wax, and tracing the design through it. The blade is then dipped in an acid which changes the color of the steel.

Hundreds of years ago, when all iron work was done at the forge, blacksmiths attained great

skill, and a few articles made by them are still to be seen in some of the cities of Europe. These smiths beat and twisted their metal into many graceful and fantastic forms. These they used in ornamenting the panels of doors to public buildings, the mighty locks of castle gates, the handles of fanciful keys, and the heads and clasps of belts.

Many of these useful articles are wonderfully small and ingenious. Padlocks are still in existence in England that do not weigh as much as a silver two-penny piece; that is, about the weight of our silver five-cent piece; and one smith exhibited a lock set in a ring which, with its key, weighed only sixteen grains.

But wonderful as these curiosities are, they are set aside by the delicate mechanisms of steel found in the works of a modern watch. No industry in the world shows the value of skilled labor so clearly as this. Pig iron sells for five or six cents a pound, and iron castings usually for ten cents, while bar iron costs about the same.

Every time any labor is put into this iron its value is increased, and an ounce of the same metal in the form of hair springs for watches is worth about $5,000. Can you find anything that shows the value of labor any better than this?

Another use of iron that we are liable to overlook is to sustain life and keep us in health and

strength. We may have to look into our physiology a moment to recall how this is. In the chapter on coal, we gave the measure of a man's work. Now the heart, in addition to this, does as much work in a day as would be required to lift a ton 120 feet, and we might also add the work done in respiration. Heat furnishes the power for all this work, and the heat is produced by the action of the oxygen on the carbon in the system.

If we look at a drop of blood through the microscope, we see little red disks floating in a yellowish fluid. Experiments show that these red blood disks contain a certain amount of iron, and that they absorb the oxygen from the air in the lungs and carry it to all parts of the system. When the blood fails to carry the right proportion of iron, we feel weak and languid. Our physician is then liable to give us a tonic containing a solution of iron. When this has been restored we feel as good as new.

Iron also enters into plants, and is necessary to the formation of the green coloring matter in the leaves. As the leaves perform the same office for the plant that the lungs do for the animal, we can see that iron is as necessary to the health of plants as it is to that of men.

The United States leads the world in the production and use of iron and steel. American

methods of organization and the use of labor-saving machinery have made it possible for this country to produce the greatest amount of iron of the best quality at the least expense. The European countries noted for their manufacture of iron are Germany, England, Norway and Sweden.

"Gold and silver and precious stones we might manage to live very comfortably without, but iron *we must* have. It furnishes almost every useful thing necessary to civilized life, being easily adapted to every requirement and purpose. It can be melted and cast into a thousand things, from a pan to a child's cot; it can be hammered and rolled into large flat plates that cover our mighty ships of war, or into lighter ones to roof our houses. It can be drawn into endless wires, some stout enough to twine and twist into an Atlantic cable, others fine enough to snip into tiny needles. It will build up any number of mighty steam engines, or it can be wrought into a handful of small nails to hold our carpet in place. It stretches far a network of lines, on which thousands of folks can travel all over the country.

"In short, iron is everywhere; rich or poor, we are all equally indebted to it. Under some form or other, it aids almost every man to earn his food, to cook that food, to cut it, and sometimes to digest it. Iron aids to strengthen him if he is weak, to

defend him if he is attacked, to build him a house to live in, to furnish it with many needful things, to give him means to travel rapidly and comfortably, either by sea or land, to carry on whatever business he is employed in."

SUGGESTIONS: Draw a map of the United States and locate the principal iron regions upon it.

When a blacksmith sets a wagon tire, he puts it on red-hot and cools it with water. Why does he do this?

Describe the different kinds of iron ore.

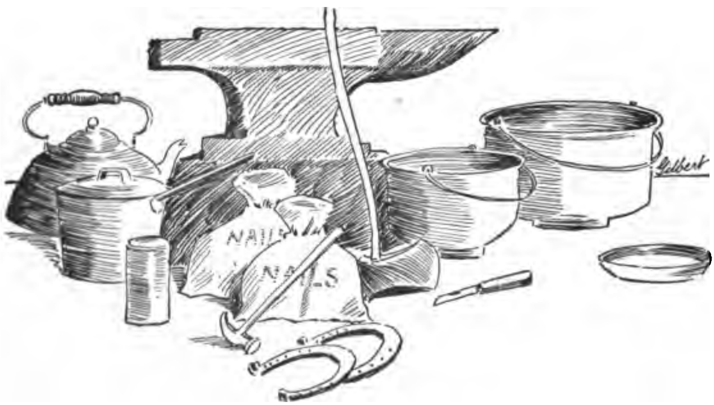
Can you learn of any countries that have used iron for money?

Iron is heavier than water, why will iron ships float?

Write a description of a smelting furnace.

Why did the Indians use copper instead of iron?

Find and name all the iron utensils in your home.



MARBLE.

IF we examine the large buildings in any town or city, we shall find three different kinds of stone in general use in their construction. These are granite, marble and sandstone, with common limestone frequently used for the foundations. If the limestone is of very good quality it may be used in constructing the walls.

It may be convenient for us to know how to tell these stones one from another when we find them, so here are the characteristics of each. Granite is very hard and is made up of three minerals easily recognized. They are quartz, feldspar and mica. The quartz looks like broken glass that has been driven into the rock. The feldspar seems to be the cement that holds the quartz in place; it presents a smooth appearance, does not show any

crystals, and is the mineral that generally gives the granite its color. The mica constitutes the little shiny, black cystals scattered through the stone, and can be picked out with the point of a knife. Sometimes the flakes are quite large, and glisten in the sun like silver.

Sandstone is just what its name indicates, a rock of sand cemented together. It is of many colors, varying from light gray to dark red and brown. It is a rock that withstands the weather well, and some varieties make beautiful buildings.

Limestone is a compound of lime and carbonic acid, and in its most common forms is a rough, coarse rock, and is found almost everywhere. Some varieties resemble sandstone so closely that they cannot be distinguished from it by their appearance. If a little muriatic acid is dropped upon the specimen, however, we can tell at once to which class it belongs. If it is a limestone the acid will break into a foam as soon as it touches the rock. While limestone is the most abundant rock and the most generally distributed over the world, it is not usually a desirable building stone, for it is coarse grained, and liable to discolor from exposure to the weather, especially if it contains impurities. It is valuable for basement walls, piers of bridges and other foundations, and for making quick lime.

Marble is a variety of limestone, and differs from

it in these particulars. It is usually finer grained than limestone, more compact and crystalline in structure. It is harder than ordinary limestone, and will take a high polish. If you examine the finished surface of a piece of marble, you can see the tiny crystals crowded together, and a small magnifying glass brings them out quite distinctly. The theory for the formation of marble is that it was once ordinary limestone, but has been changed to its present state under intense heat and great pressure. Pure marble is snow white, but there are almost all colors and shades between this and jet black. This variety of colors is due to impurities that blended with the rock in its formation, and is quite an advantage, as it produces marble suitable for nearly all purposes for which stone is used.

Marble also varies in degrees of hardness and ability to withstand pressure, and the action of the weather. Some varieties are of much coarser grain than others, those of the same locality often differing widely in this respect. However, all marbles may be grouped into four classes.

1. The pure, simple or single colored marbles.
2. The variagated.
3. The brecciated, those made up of fragments of other rocks cemented by the limestone.
4. The fossiliferous, those made up in whole or part of fossils.

To these might be added that known as serpentine, and verd antique, which is of a beautiful green color, and differs in its composition from ordinary marble.

While marble is found in nearly all countries, it does not occur in good quality in but few places. Among these Italy, the islands of the Mediterranean and some sections in the United States are the most noted. A little is taken from the British Isles and the countries of Europe, some from western Asia, and some from Africa. The United States and Italy produce the greater part of all that is used.

HISTORY.

A complete history of marble would form a large book, for this stone has been known to many nations and through many centuries. The ease with which it could be worked made it one of the most useful stones in early times, before the use of steel tools was known. Many of the most celebrated buildings of Ancient Athens and of Rome, as well as the statues of the most famous Grecian sculptors, were made from marble. The reputation of some of these ancient quarries was such that the name of their marble is still in use. We notice especially the Parian marble, so called from the

Island of Paros where it was quarried. This is a little island in the Mediterranean, southeast of Greece, a mere dot in the sea; yet its marble has made it famous in all lands and for all time. The Parthenon at Athens, and Venus and Diana, two of the most celebrated statues of the world, are among the works made from this marble. Parian marble is the finest in the world; it is pure white, of very fine grain, and especially suited for statuary.

The marbles of Mount Pentelicus and Mount Hymettus, near Athens, were equally celebrated in their day, but we hear nothing of them now. The marble which has been quarried and used since the founding of the Eternal city to the present time is that of Carrara, Italy. Carrara marble is white as snow, and is beautifully compared to it by Lowell in the line,

"From sheds new-roofed with Carrara."

It has a fine structure resembling loaf sugar; is of finer grain than most marble found in the United States; and constitutes three-fourths of all that imported into the country. We will learn more about this marble and the people who work it further on in our story.

MARBLE IN THE UNITED STATES.

Marble is found all along the Appalachian Mountain System from Vermont to Georgia, and

is quarried to a greater or less extent in every state this system crosses. A little is found on the Pacific slope, and some has been produced in Idaho.

Vermont and Georgia are the great marble producing states of the Union. Vermont marble is known the world over, and more than two-thirds of all the marble produced in the country comes from the quarries in that state. Georgia ranks next in importance, but the quarries in that state have not been worked as long as those in Vermont, and the marble has not yet been as extensively placed on the market. The stone is of excellent quality, and is fast gaining favor, so that within the next few years, this state bids fair to become a rival of Vermont in the marble industry. Tennessee and New York also produce marble to some extent.

A MARBLE QUARRY.

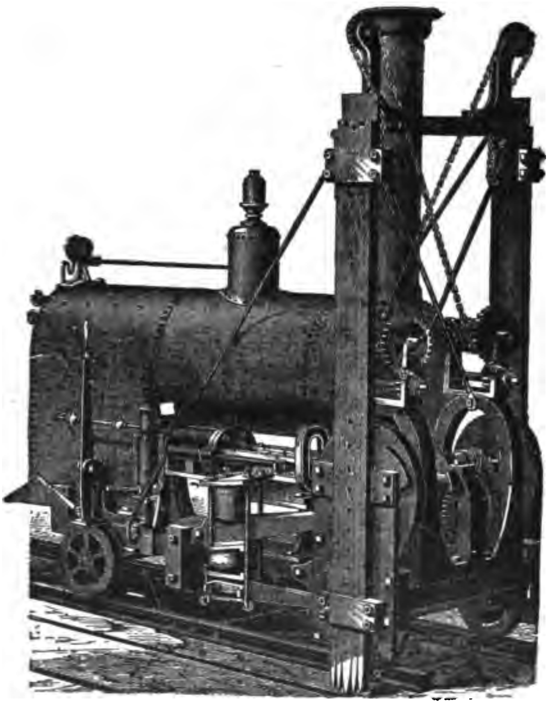
The marble quarrys among the Green Mountains are among the most interesting places one can ever visit, either in our own country or foreign lands. The marble lies in irregular beds extending from north to south, and outcrops in various places along the mountains, but most of it is beneath the surface. The layers incline a little to

the west, and soon take one far under ground when followed into the side of the mountain. Some of the largest quarries, however, are in open, level places, and have been dug directly downward. These are the most interesting to visit.

The upper layers of rock are usually of poor quality, and, at best can be used only for the roughest building purposes. On account of this, the opening of a quarry is very expensive. Sometimes $75,000 or $100,000 have to be expended before stone of good quality is obtained.

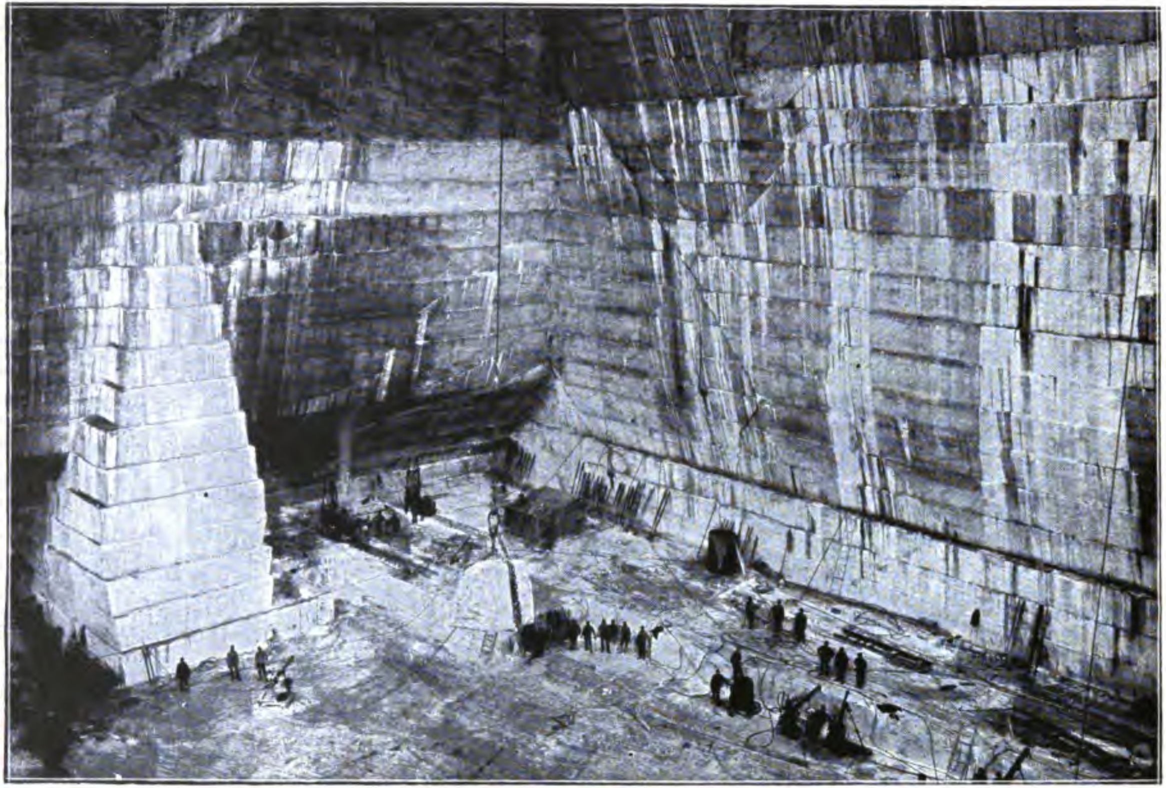
Most marble quarries differ very much from a mine. The quarries are open at the top, and have no shaft. The rock lies in layers varying in thickness from two to ten feet. When the surface rock has been removed, channeling machines are put to work on the floor of the quarry. This machine is for the purpose of cutting the marble into blocks, and is one of the most important appliances of the quarry. It consists of a series of chisels or drills arranged on one or two sides, and worked by steam or compressed air. The machine moves back and forth over a railway track, and its chisels work very fast. One channeling machine can cut a channel seventy-five feet long, and five feet deep in a day, that is equal to the work of twenty men.

Two channels are first cut the length of the quarry, and this separates one course, called the "key course," from the rock on either side. This



CHANNELING MACHINE.

course is then cut up into blocks, and the first of these is loosened either by blasting or with wedges. When this has been removed, another machine, called the gadder is set to work to loosen the other blocks. The gadder is a machine for drilling into



MARBLE QUARRY, WEST RUTLAND, VT.

the rock in a horizontal direction. It contains a number of long, slender drills about six inches apart. These drill into the rock with great speed. When the holes have been drilled, long wedges, called gadding pins, are inserted, and driven in tightly. These wedges separate the block from the layer beneath, and it can then be hoisted from the quarry. When one course has been removed, another is cut, and so on, until the entire floor has been taken out. In this way one layer of stone after another is hoisted, and the quarry sinks into the ground.

Some of the quarries that have been worked for a long time are quite deep. One at West Rutland is now more than 500 feet below the surface, and a portion of it has been tunneled, and has a great arched roof of rock suspended several hundred feet above the floor. As in the coal mine, pillars have been left occasionally to support the roof. Failure to do this when the quarrymen first began to tunnel led to a number of serious accidents from falling rock.

When we descend to a coal mine, we go down in the miners cage, but if we would visit a marble quarry, we must go down a long, winding stairway fastened to the side of the quarry. This stairway is open, and one can see the yawning depth of the quarry from the time he begins the descent. A

person who gets dizzy looking off a great height, seldom makes the attempt; he might fall headlong and make his appearance among the workmen below some time before they expected him.

When once on the quarry floor, a look upward repays all the effort made to reach the place. On all sides are the towering walls of marble, arranged in its natural bed in layers as even as could be devised by the most skillful architect, while over a part of the excavation arches the great dome of the roof. This is a sight grand beyond description; the effect of these immense walls surrounding us is peculiar and awe-inspiring. We feel that we are inclosed by a fortress reared by gigantic hands, and one that would be a protection from all force that might be brought against us.

What force fashioned these massive layers of rock and so perfectly adjusted them one upon another? How old these treasures are. For ages before man lived; yes, long before the coal was, they began to form. And here they have lain these thousands of years in a perfect state of preservation, until man was civilized and educated, and could use them to beautify his dwelling places and increase his happiness. This quarry and all the other subjects we have studied in this book bear eloquent testimony to the truth of what the English writer, Addison, wrote many years ago:

"The spacious firmament on high,
With all the blue ethereal sky,
And spangled heavens, a shining frame,
Their great Original proclaim.
The unwearied sun, from day to day,
Does his Creator's power display,
And publishes to every land
The work of an Almighty hand.

"What, though in solemn silence all
Move round the dark terrestrial ball;
What, though no real voice or sound
Amidst their radiant orbs be found,
In reason's ear they all rejoice,
And utter forth a glorious voice,
Forever singing as they shine,
'The hand that made us is Divine.'"

Men are engaged all about us removing the marble from its natural bed to the regions above. We are surprised at the small amount of heavy lifting required in moving these great masses of rock. Machinery does the work, and the workmen guide the machines. Channeling machines and gadders are at work cutting the stone into blocks, which huge derricks are raising out of the quarry. The blocks are usually six and a half feet long, four and a half wide, and four thick, but may be made of any size that the derricks can lift. It is not uncommon to see blocks fifty feet long

loosened from their bed. The greatest care is taken to prevent waste and injury to the stone. By use of the machinery now employed the stone can be cut as regularly as lumber, and with as little waste. The deeper the quarry, the better the quality of marble obtained, so the extra expense is made up by the increased value of the product.

Formerly all work was done by hand, and every quarry was swarming with men, each driving his long slender drill into the rock. Marble quarried in this way was so expensive that only a few could afford to use it, and this in but small quantities. Now, thanks to the ingenuity of American workmen, marble is no more expensive than any other good building stone. A careful study of the view of the quarry will help to understand the methods of work. At the left, two channeling machines are cutting courses in the floor which has been partially removed; in the center, the derrick has just started a huge block on its upward journey; while against the wall stand the tools of the quarrymen. We notice that a pillar has been left in front for support, and that the quarry is being tunneled at one end.

This is a view of the average marble quarry, and nearly all others have a similar appearance, the difference being due to size and location. If the quarry is on the side of a mountain the opening is at the side instead of the top.

All methods of quarrying are about the same. In the American quarries, little or no blasting is allowed. There are two reasons for this; one is that the blast breaks the rock into irregular pieces, and wastes a good deal, and the other that the powder sometimes enters the stone and causes it to discolor after it has been in use for some time. In the Vermont and Georgia quarries, the work is so carefully done that the waste does not exceed one-fourth of the rock loosened. In the Italian quarries, where all the rock is loosened by blasting, nearly nine-tenths of it is wasted.

The mills where the marble is finished are also of great interest. Here too we find nearly all the work done by machiney. The blocks are first sent to the saws, where they are cut into slabs of various thickness, depending upon the use to which they are to be put. Those intended for wainscoting may be from three-fourths to seven-eighths of an inch, while slabs for headstones and window caps may reach a thickness of six inches.

The saws are plain strips of soft iron about one-eighth of an inch thick, and without teeth. The following description is taken from a circular of the Vermont Marble Company, and gives a good idea of the machine.

"These bands, or saws as they are called, are securely fastened to a movable iron frame at differ-

ent intervals, depending upon the size into which the blocks are to be cut. Each of these frames is called a gang, and at times as many as sixty saws are placed in a single frame. Into these gangs the blocks are drawn, and the frames are fed down upon them by their own weight. The saw gangs

YARD AND MILLS.

are kept constantly running day and night, and present a busy appearance as they move back and forth over the marble, a hundred strokes a minute. The real sawing is done by a combination of these iron bands with sand and water, the constant rubbing of the sand by the saws gradually wearing them down through the marble. The speed with

which marble is cut varies largely with the hardness of the marble; the average cutting being from an inch to two inches an hour. The blocks sawed are generally about six feet by four feet square. One of our gangs will saw a block eighteen feet six inches by ten feet. This is probably the largest gang in the world."

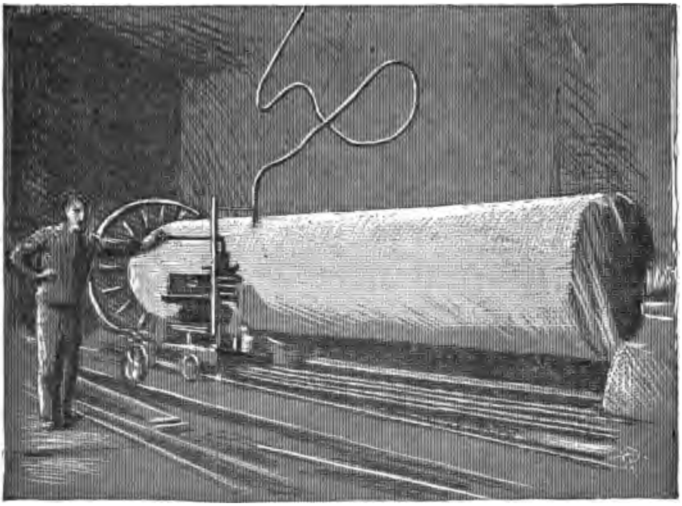
The sawing leaves a rough surface similiar to that on a board, and the next step is to smooth this on a rubbing bed. The rubbing bed consists of a large circular iron plate, revolving horizontally, water constantly flows over the surface, and the smoothing is done by the combined action of the sand and iron. Some of these beds have huge tongs so adjusted that they can smooth the surface of a block weighing ten tons.

We also find planing machines for shaping mouldings and the edges of panels and table tops, and lathes for turning caps, bases and pillars. One of these lathes can turn a block weighing ten tons, and another a pillar twenty feet long and three feet in diameter.

Polishing is done by a machine called a buffer. It is a rapidly revolving wheel covered with flannel charged with a substance known as putty powder. The wheel is capable of horizontal movement in all directions, and can be brought in contact with all parts of the surface. Much of the polish-

ing of carved and curved surfaces, however, has to be done by hand.

All light carving, or skin work, as it is called, is done in the old fashioned way with the mallet and hand cutting tool. But a tool for this purpose



TURNING A PILLAR.

has been recently patented which delivers a large number of light blows a second, and is driven by steam power. This is now used to some extent.

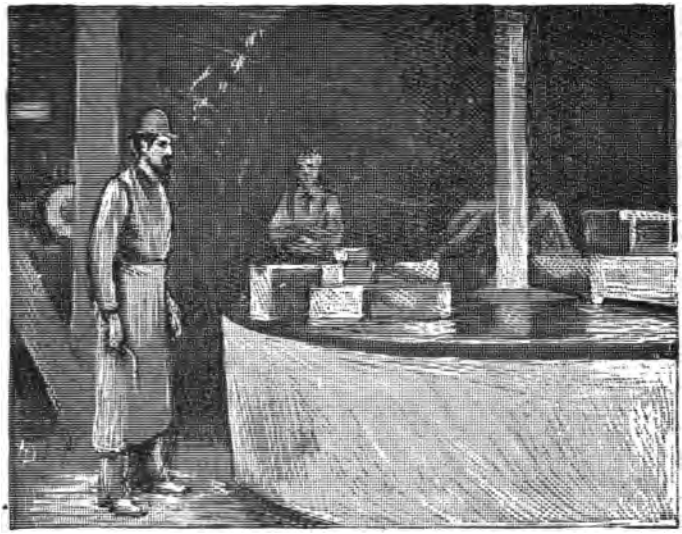
Ornamental work on buildings and monuments requires artistic taste and work of greater skill than any machine can be constructed to do, hence these designs must be engraved by hand.

Georgia marble is valuable for building stone on account of its hardness and great strength. The quarries are located in the northwestern part of the state, and are on a portion of the land from which the Cherokee Indians were removed by the United States Government. These Indians knew something of the stone, and the ease with which it could be worked. Some of them used it in the construction of chimneys, and for steps to their houses. Near the works of the Georgia Marble Company is a circular marble bowl of Indian construction, and in the same locality a large marble bowlder has been found, in which was excavated a bowl about eighteen inches in diameter. This was probably used by the Indians in grinding their corn, and is supposed to have been made long before the country was known to the white men.

The Georgia quarries are practically inexhaustable, and the methods employed in working them are the same as those already described. The mills connected with these quarries are new and among the most perfect in the world. While Georgia marble has been more generally used in the South, it is rapidly finding its way into the northern markets, and will soon be a strong competitor with that from other localities.

VARIETIES AND COLORS.

We have said that all marbles could be grouped under four classes, but to assort these classes and place the different colors and shades by themselves would be no easy task. Each class has many col-



RUBBING BED.

ors, and each color many shades. The marbles of Rutland County, Vermont, range from pure white to dark blue and almost black. A greater part of them are mottled, this being due to the blending of some impurity during their formation. Most of

the mottled marble of this locality is a blending of the blue and white, but a little has a green coloring. This is of coarser structure, and is not considered as valuable as the other.

In selecting stone for mouldings, wainscoting, and other trimmings, great care must be taken to get pieces that will harmonize in grade and color. One firm in Georgia has built up an extensive business in finishing work by giving special attention to this feature of it.

Strange as it may seem, the slabs cut from the same block sometimes differ so much that they cannot be used side by side, in mouldings or wainscoting. As these peculiarities are only clearly brought out when the stone is polished, it requires an experienced workman to make selections.

The marbles of northern Vermont are of a red and white mottled variety, turning to pink and almost flesh color. These marbles take a high polish, and are extensively used for trimmings. Sometimes they are employed for wainscoting in halls for public buildings. Some of the marble found on the islands in Lake Champlain is black, but most of it belongs to the fossiliferous class, and is of a dark gray color. When polished, this stone is something of a curiosity as well as an ornament. The petrified fossils are white, or nearly so, and their forms are brought out very

distinctly in polishing. This marble is used for mouldings, mop-boards, tops of radiators, and in many places where a trimming is required in mild contrast to the other finish. Much of the Tennessee marble is of the same character.

The red, black, gray, blue, dark blue, and "mountain dark" varieties of the Vermont marbles are extensively employed in trimmings and set off the white and mottled varieties in beautiful contrast, that no painter or decorator may ever expect to equal. The serpentine marble of Italy is also valuable for this purpose. When polished, this variety has a beautiful dark green color, and sometimes a green and gold. Some of the finest specimens to be seen in this country are in the pillars in the Board of Trade building in Chicago.

Monuments, headstones, and statues still claim the greater part of the attention of the marble industry, however, and much more marble is given to these purposes each year than is used in the construction of buildings. Marble monuments and headstones mark the resting places of our loved ones in the cemeteries; marble statues adorn the parks of our large cities, and the crypts and niches in the walls of our public buildings. We owe much to this stone; it has preserved for us the wonderful works of the ancient sculptors; it educates our taste by the beautiful objects con-

structed from it, and the beautiful buildings it makes possible.

THE QUARRIES OF CARRARA.

No greater contrast can be found than that between the marble quarries of the United States and those of Carrara. The Carrara quarries are situated in the Appenine Mountains, about ninety miles from Genoa. The mountains at this place seem to be made up of pure white marble, and from these quarries the stone has been taken ever since it began to be used in the statuary and buildings of Ancient Rome.

Notwithstanding the advancement that has been made in methods of working the stone, and the many ingenious machines that have been invented for this purpose, the quarrymen of Carrara employ the same old tools and the same old methods that were in vogue centuries ago. In the American quarry all the work possible is done by machinery; in Carrara it is done by hand. The marble in America is worked up in mills employing a large number of men; in Carrara, every man's basement is a studio where the artist does his work alone.

The Carrara quarries are far up on the mountains, and the quarrymen often drill for hours sus-

pended in mid air by a rope. The rock is blasted out, and great pieces are frequently dashed to fragments by being hurled down the mountain side.

METHOD OF MOVING MARBLE IN MINES OF CARRARA.

The Italians are born sculptors and artists, and more statuary comes from Italy than any other country in the world. Many American workmen engaged upon the finest work in this country have been to Italy to learn their art from these Italians.

GRANITE.

WE have already learned of the composition of granite and how it can be distinguished from other rock. The term granite as it is used in commerce includes more than it does in its strict scientific sense.

Granite in commerce means all stone that has the appearance of granite, whatever its composition may be, and includes syenite, a rock that closely resembles granite in appearance, but in its composition has hornblende in the place of mica.

Hornblende is a fibrous mineral found in a variety of forms. In syenite it occurs in crystals, usually of dark color, varying from green to black. It is firmer than mica, and makes the rock into which it enters harder and stronger. Many of the best granites are really syenites.

The name granite means granular or grain like, and is given to this rock on account of its peculiar structure and appearance. Granite is one of the oldest rocks in the earth's crust, and was once in a molten state. When it cooled each mineral crystalized separately, but all were firmly cemented together, forming the hardest and strongest rock in use.

The country may be divided into three granite sections; the eastern, middle and western. The first includes the Appalachian slope and the Atlantic coast; the second the Mississippi valley; and the third the Rocky Mountain system and Pacific slope. The eastern section is worked principally in New England and Georgia; in the middle section Missouri, Minnesota, South Dakota, Wisconsin and Arkansas have developed quarries to some extent. The western section is practically undeveloped, California being the only state worthy of mention as producing granite.

Granite occurs in most mountainous regions all over the world, but it is not suitable for quarrying in but few localities. A granite country is always rough and mountainous, with clear streams and a good soil, provided a quantity of the rock has been changed into soil. In some localities we find hills and even mountains of solid granite, as in New Hampshire, which is called the Granite State. In

other places we find bowlders scattered over the meadows or prairies and far from any parent mountain or ledge. These bowlders have a rounded shape and look like sheep lying on the ground. On this account they have been called sheep backs by some geologists.

We wonder how these rocks came here, so far from any other rock of the same kind. To understand this, we need to look to the Alps and the northern part of the Rocky Mountains and notice what is taking place there at the present time. We find the ravines and smaller valleys among these mountains filled with melting snow, forming rivers of ice called glaciers. They move slowly down the side of the mountain and carry along with them whatever stones or other deposits they may receive. The glacier melts at the bottom, and a stream of water is always running from it. As it melts, it drops the loose rocks that have come down the mountain on its surface, so we find at its foot a lot of stones resembling those found in our meadows.

These bowlders tell a story of a time when the climate of our country was very different from what it is now. The country was then a land of icebergs and glaciers. They covered the entire surface, and held everything in their frozen grasp. All plants and animals had perished, and the con-

tinent was a wild waste of ice and snow. This was before man lived upon the earth, but after the coal period.

When these masses of ice began to melt they took a sliding motion towards the south-east, and carried along all the loose rocks that had been frozen into them. As the glaciers melted they dropped their burden, and we have the bowlders scattered over the land. The rubbing against each other and on the rocks over which they moved gave the bowlders the shape they now have.

The moving of this mass of ice and stone over the outcropping ledges plowed deep furrows in some of them, and smoothed and polished others. The furrows and scratches thus formed are called striae, and point to the south-east; this tells us in which direction the mass moved.

The great masses of granite that are quarried in this country are situated in the Appalachian region, and are worked principally in New England and Georgia, with smaller quarries in Maryland, Pennsylvania and New York. The amount of granite in any one of these localities is sufficient to last the world for ages to come, so there need be no fear of its giving out in our day at least.

HISTORY.

The people of ancient Egypt were the first to

make use of granite for buildings and monuments. The stone used was a red syenite, and is very hard and durable, as the ruins of their works show. The stone was taken from quarries up the Nile and floated down to the place where it was to be used. The high degree of polish and elaborate carving with which these people finished their granite shows a great degree of skill on the part of their workmen. Their engineering skill must also have been equally good, for they moved blocks of great size and weight. In the Great Pyramid, whose base covers more than twelve acres, are found stones four feet square, and thirty feet long, and the shafts of some of their monuments were more than sixty feet in length. We do not know that they had any knowledge of steam power, or that they even used beasts of burden. To move stones of this size by the labor of men alone must have required an army of laborers and skillful management.

In the center of the Great Pyramid is a chamber forty-six feet long, twenty-seven wide, and eleven and a half high. The walls of this chamber are of polished granite of a beautiful red color, and the slabs are as long as the walls are high. The ceiling is formed of nine immense slabs of the same stone. Still standing on the banks of the Nile, not far from Cairo, is one of those monuments

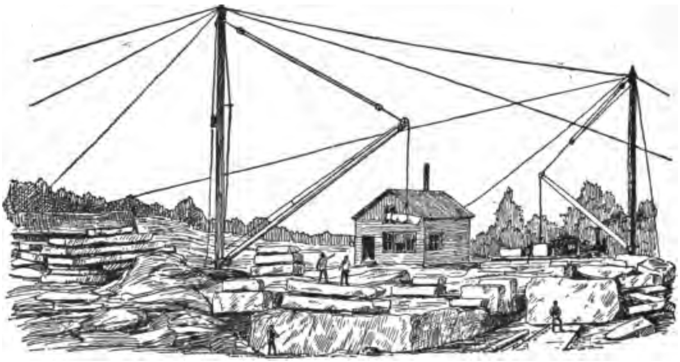
commonly known as Cleopatra's Needles. This single shaft rises sixty-eight feet above the mud which has covered its base. Some one has fitly called it the "grave stone of a buried city," for it is all that remains of that wonderful city where Joseph lived and ruled, and made himself known to his brethern. This monument was reared nearly 3,000 years before Christ, and has with-stood the ravages of time for all these ages.

Another of these monuments was a few years ago placed in Central Park, New York, and has been of great interest to the thousands of visitors who frequent the place. These stones have been diligently studied by certain historians, for the history of the time in which they were erected is written upon them in the picture writing of the Egyptians. These historians have learned to read and translate the hieroglyphics, and from them we have obtained much knowledge of the life and customs of this ancient people. That the figures are in almost a perfect state of preservation is due to the wonderful durability of the granite.

The art of polishing and carving granite seems to have been lost for centuries after the decline of Egypt. In 1856, a statue of one of the Pharaohs was brought to the British Museum. The head had been broken off, and it became necessary to

fasten it to the body by inserting a strong iron rod to hold it in place. It took the workmen six weeks to drill the holes for this rod, and they broke several tools of the best construction during the work. How do you suppose the Egyptians carved the statue?

Up to the present time the New England states have been the center of the granite industry in this country. This is not because they contain more



GRANITE QUARRY.

granite than several other localities, but because the location of their quarries has been very much to their advantage. Most of the New England quarries are so located that they can ship their stone by boat to nearly all places using it. They are also near most of the large cities of the country, so granite can be obtained from them cheaper than from any other quarries. These are important

factors in handling an article whose transportation is so expensive.

The first of these quarries was opened in Quincy, Mass., in 1820. The development of this quarry is connected with two events of national importance; the construction of the first railroad in America, and the erection of Bunker Hill Monument. The railroad extended only from the quarry to the wharf on the Neponset River, where the stone was loaded on to the boats. The rails were of wood, and the stone was carried on a platform that was suspended under the car and raised and lowered with a windlass.

Daniel Webster, in his great oration at the laying of the corner stone of Bunker Hill Monument said of it: "Springing from a broad foundation, rising high in massive solidity and unadorned grandeur, may it remain as long as Heaven permits the works of man to last, a fit emblem, both of the events in memory of which it is raised and the gratitude of those who have raised it." Such are the enduring qualities of Quincy granite that no more suitable stone could have been selected for the purpose of carrying out Mr. Webster's wish.

The first recorded use of Quincy granite is in the construction of King's Chapel, Boston, in 1752. The stone was taken from bowlders lying about the North and South Common, and so many were

used that it was feared the supply would be exhausted, and several town meetings were held to discuss the matter. It seems that the people had no knowledge of the value of granite in the immense ledges about them, nor of the means of quarrying it.

Granite had been quarried in New Hampshire before the Quincy quarries were opened, but it is with the large contract of these quarries for Bunker Hill Monument that the industry may be

THE OLD WAY.

said to have really begun. From this beginning the demand has continually increased as years have added population and wealth to the country. In 1893 the three largest granite producing states were Massachusetts, Maine, and Vermont. New York, Pennsylvania, Maryland, Georgia and Minnesota also produced considerable.

The quarries in Quincy differ from those in other localities in that they are operated by a number of small firms instead of large corporations. Some of these firms give their entire attention to quarrying the rock, others to finishing it, and still others

to the manufacture of cases in which the finished stone is shipped.

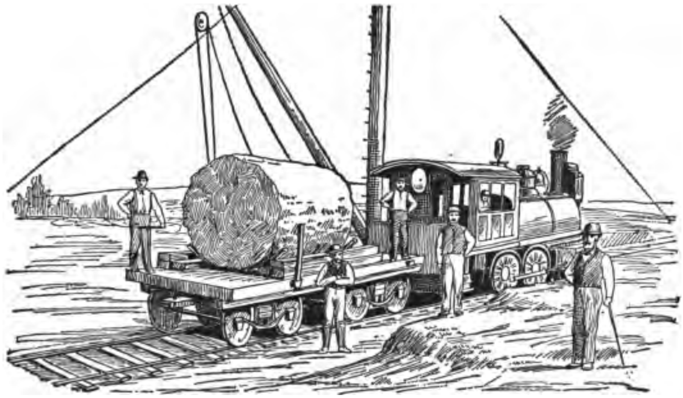
Some of the most noted New England quarries are on the islands off the coast of Maine, those on Dix, Fox and Hurricane Islands in Penobscot Bay being among the most valuable quarries in the country. Others are located along the indentations of the coast. The largest quarries in Vermont are located at Barre, and the quality of the stone is such as to place this state third in rank in 1893, when in 1889 it was ninth. Certain quarries in Connecticut furnish an excellent stone, and the "Westerly" in Rhode Island is superior for monuments and ornamental purposes.

Large deposits of granite of excellent quality are found in the northwestern part of Georgia. These quarries have been worked only a short time, but their product is in a fair way to become a strong competitor with that of the older quarries of New England.

In the middle belt, the granite of St. Cloud, Minn., is worthy of special mention as a rock of great strength and durability. Stone from these quarries has endured the highest pressure test of any in the country. The quarries at Ortonville also furnish a stone of excellent quality, and the massive Hennepin County Court House at Minneapolis is constructed of this granite. On account of the

expense in transportation the product of the Minnesota quarries has not been very generally placed on the market.

The western belt is not yet developed, but as that section of the country becomes more densely



THE NEW WAY.

populated these fields will furnish abundant building stone for all demands.

QUARRYING AND WORKING.

A granite quarry differs materially from a marble or slate quarry. The granite is usually found on or near the surface, and in many localities is cut from the side of a mountain of the solid rock. Most of these quarries can be worked for years without sinking below the level of the surrounding

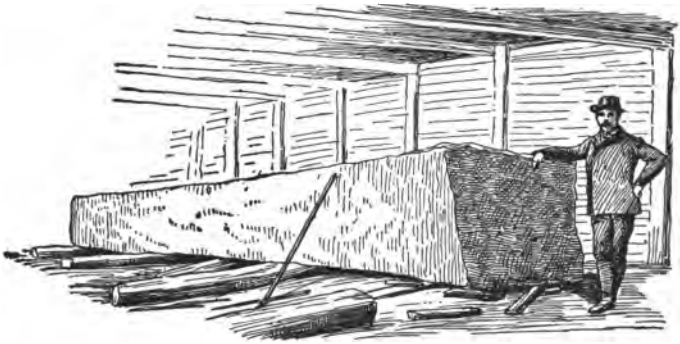
land, or at least going to a great depth, however, they frequently extend over a large area. The rock usually occurs in layers, or "sheets," as the quarrymen call them. These sheets vary in thickness from two to ten feet, and can usually be split into courses without incurring much waste, though granite cannot be worked as economically as marble.

Blasting has been found to be the most satisfactory method for loosening the rock, provided the blast is pretty sure to split it in the required direction. Care must be taken to direct the force of the explosive along the line where the stone is to be broken. There are several methods of doing this.

The first is called "lewising." Two holes are drilled a few inches apart on the line of desired fracture; the core between them is then broken out. The explosive is placed in this elongated hole, and tamped the same as an ordinary blast. If a very long fracture is required several holes are drilled along the line, and the charges are all fired at the same instant by electricity. The powder exerts the greatest force in the direction of the longest diameter of the hole, and breaks the rock as desired.

Another method is to drill a good sized hole to the desired depth, and then cut V-shaped crevices on opposite sides along the line of fracture. A plug is driven in above the powder so as to leave a

cushion of air between it and the tamping. This allows the explosive to act upon the rock more gradually, and removes the danger of shattering it into small pieces. This method is quicker, and less expensive than the other, and is usually very effective. Sometimes small holes are drilled along the line, and all fired at once. This can be done very well when the rock breaks readily and easily.



BLOCK OF GRANITE.

When blasting cannot be resorted to without great waste, small drills are used, and the holes are placed only a few inches apart. Steel lips and wedges are placed in these and the rock is split off by driving on the wedges with a heavy hammer. The old way of doing this was to make crevices in the rock and insert wooden wedges, and then cause the rock to split by wetting the wedges and making them swell. This shows how much power there is

in a small quantity of water when it is used in the right way.

Very large blocks are frequently quarried by these various methods. Sometimes a free fracture 125 or 130 feet in length is made by the blast from one lewis hole. At the Mt. Waldol quarry, Maine, a block 125x20x14 feet and containing 30,000 cubic feet, was loosened. Such results can be obtained only when the rock is free at the ends and underneath, and has room to move out in front.

A quarry in Missouri was mined; that is, a shaft was sunk and chambers, or drifts, were extended in all directions from it. These drifts were filled with explosive and the mine was fired. The blast loosened enough rock to last the firm for fifty years.

The methods for handling granite in transit resemble very closely those used in handling marble. The principal difference is that the size of the blocks is larger, and the machinery needed heavier. The cable railway is employed in many quarries to move the blocks to the cars or sheds. This is made of a strong wire cable composed of steel and copper wires. This is fastened to a high tower at each terminus. The car is suspended to this and moves on a grooved pulley. The car may be a platform on which the stone is piled, or it may be a clamp that is firmly fastened to the large blocks. A hoisting

engine is connected with another wire rope that moves the pulley along by being wound around a drum. When the car is loaded the engine is started and the stone begins its journey through the air. If the quarry is on the side of a mountain, the engine unwinds the cable and the stone moves by its own weight.

The sheds where the granite is finished present a busy appearance. Much the same machinery is

CABLE RAILWAY.

employed as in the marble mills, but a greater amount of work has to be done by hand. Granite does not split evenly, nor break with smooth surfaces, and most of the blocks have to be evened and partially worked down before they can be worked by the machines. Then many of the different styles of finish must be done by hand, though a finishing tool driven by steam or compressed air has recently come into use. This machine strikes light blows very rapidly, and can do the work of

several men. In the hands of a skillful operator it is very effective.

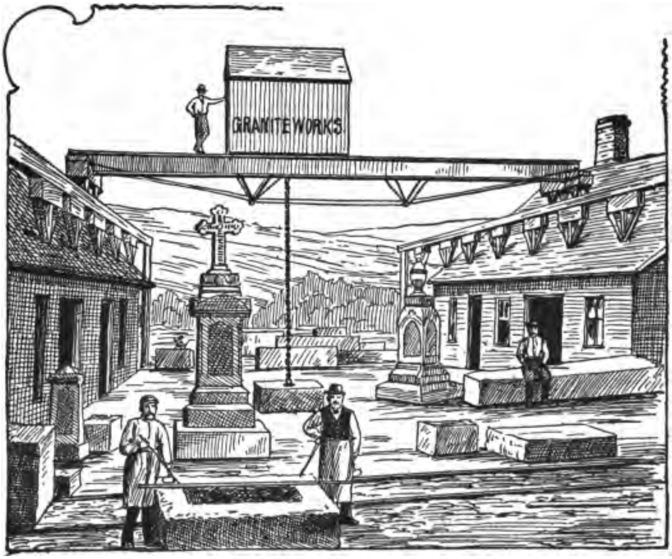
All hand or machine finished surfaces have to be ground before they can be polished. The grinding is done with a rapidly revolving steel disk made of rings placed one within another. The disk revolves horizontally, and is so arranged that it can be brought in contact with every part of the surface. The grinding is done by water and steel emery or sand. Granite is polished with a buffer and putty powder the same as marble. Lathes are used for turning pillars and shafts, and special devices are employed for polishing curved surfaces.

Granite is so hard that it requires the best of tools and strongest machinery to work it successfully. Much more time is also needed to work a piece of granite than a similar piece of marble. On account of this granite is more expensive than most other stones in general use.

VARIETIES AND USES.

Of all stone quarried in the United States, granite can be applied to the greatest number of uses. It is so hard that it posesses great strength, and so durable that the action of the weather has no effect upon it. It can be carved into any form, and finished in any style of surface. It takes a higher

polish than marble, and has nearly as great a variety of colors. The colors range from almost white in the grays to blue and nearly black, and from light pink to dark red. Occasionally a variety with a greenish tint is found, but it is not common.



Granite is employed for public buildings and other large structures in cities for which its massive appearance and great strength make it suitable. Some quarries are pretty well known over the country by the public buildings for which they have furnished stone. A good illustration of this

is the Vinal Haven Quarry in Maine. Granite from this quarry is found in the buildings of the State and War departments at Washington; the Auditorium and Pullman Building, Chicago; the Federal Building, Brooklyn, and the polished granite surfaces in the State House at Indianapolis.

The readiness with which granite yields to treatment, enables the architect, by different styles of finish to obtain pleasing contrasts with harmony of color by using only one kind of stone. This makes this stone especially suited to building purposes.

Another extensive use of granite is in the construction of streets and roads. It has been found that the busiest streets in great cities stand longest and serve their purpose best when paved with stone. Granite makes an excellent paving stone because it is hard enough to stand wear well and brittle enough to keep from wearing smooth. The paving block industry has assumed large proportions, and is quite remunerative to the companies. The blocks are usually four and a half inches wide, six or seven deep, and eight or twelve long. They can often be cut from what would otherwise be waste, but are sometimes worked directly from the sheets. The sheets are broken by hammers into strips the width of the block, and these are then broken into blocks. A successful workman on paving blocks must be able to tell at a glance in

what direction the stone will split the most readily, and must be skillful in the use of his hammer.

The manufacture of curbing stones forms a good part of the business of some quarries. Curbstones are from six to twelve feet long, six to eight inches wide, and about two feet deep. The stones are dressed at the ends so as to make a good joint, and on the top and for a few inches on the back next to the walk. When we think of the miles of curbing in our cities, we can see that this branch of the granite industry alone would make a large business.

Granite is also used in paving streets where a smooth surface is required. For this purpose the stone is either broken into small pieces by hammering, or in crushing machines when a small size is desired. The crushed rock is then mixed with a cement and rolled down under a heavy pressure. When the cement hardens, we have one of the finest road surfaces that can be made.

A few years ago all the granite monuments in our cemeteries came from Scotland. The stone is of a rich red color, very hard, and takes a high polish. It was soon discovered that American granite could be polished as well as that brought from Scotland, and now only a few Scotch monuments are purchased. Granite furnishes excellent material for monuments on account of its durability and the great beauty of its polished surface.

We also find granite supplanting marble for outdoor statuary in our public parks and many of the largest monuments. Some of these monuments are among the most beautiful works of art to be seen in the country, and their shafts will rival in size and beauty those of the Ancient Egyptians mentioned in the first pages of the chapter. The Soldiers' and Sailors' Monument in Boston Common, and the monument erected at Plymouth, Mass., to commemorate the landing of the Pilgrims, are among the most celebrated. As we noticed how the Egyptians wrote their history in stone, let us look at this monument and see how the same thing is done now.

The base of the monument is forty-five feet high and supports a statue of thirty-six feet. The main pedestal is in the form of an octagon with four large and four small faces; from the small pedestal project four wing pedestals, or buttresses.

The statue on the main pedestal is a majestic figure of Faith. One foot is firmly planted on Plymouth Rock. The left hand holds a Bible and the right hand points towards Heaven. The face, which has an expression of sublime trust, is bent downward. The length of the outstretched arm is nineteen feet and ten inches; the head at the forehead measures thirteen feet and seven inches, and

the arm just below the short sleeve, six feet and ten inches in circumference.

On each of the four pedestals are seated figures which represent the principles by which the Pilgrims were guided in founding the state. The figures are Morality, holding the Decalogue in one hand and a scroll of Revelation in the other; Law, with Justice and Mercy; Education, with Wisdom on one side and Youth led by Experience on the other; and Freedom, with Peace under her protection and Tyranny hurled down from power.

Upon the faces of the projecting pedestal are reliefs representing scenes from the history of the Pilgrims, the departure from Delft-Haven, the signing of the compact, the landing at Plymouth, and the first treaty with the Indians. This wonderful story in stone is told as eloquently and even more beautifully than are those chiseled by the Egyptian sculptor upon his ancient obelisks.

SUGGESTIONS:—See how many different kinds of granite you can find, and explain the different colors.

How can you account for the shape and smoothness of granite pebbles?

Compare a granite and a marble monument and describe the difference in the structure of the rock.

SLATE.

YOUR slate was about the first object you took to school and you probably felt that you were a very important person when it was given you. You used it to scrawl on for amusement; you wrote your first words on it; and, in time, you puzzled your brains in working the "sums" your teacher gave you to cipher out on it. Did you ever wonder where slate came from, or think of the many other purposes for which it is used?

The term slate includes many different kinds of rock, but that described here is composed of clay and silex, which is the most important mineral in common sand, and is generally known as clay slate. This rock occurs in layers, or strata as the

geologist calls them. The layers are found lying in all positions from horizontal to vertical. In some places they were folded like cloth or paper before the rock was hardened. If these folds are small they render the slate worthless, but in most places the layers can be split into pieces large enough for use.

The principal slate quarries of the country are located in Pennsylvania and Vermont. Those of Pennsylvania are the largest, and those of Vermont furnish slate of the best quality. The most noted slate quarries in the world are in Wales.

Slate is a soft rock, easily split into thin layers, and of a variety of colors. The most of it is bluish-black; some is light-green, some red, and some purple. It also varies in hardness and structure, some varieties being much finer than others. The soft varieties are the most valuable, and are used for the finest work.

A slate quarry differs from that of any other kind of rock. The stone is in thin layers, and must be loosened in a certain way or it will be worthless. Blasting is resorted to only when no other method of loosening the rock can be employed, and this is usually at the opening of the quarry. The quarry follows the dip, or slant of the strata, and in time becomes quite deep. Grooves are cut in the rock to limit the size of the

slabs split off, and the loosening is generally done with wedges. The slabs when loosened from the ledge are about four feet square and a foot thick; but may be larger if the layers will admit of their being made so. These large blocks are removed from the quarry and split into slabs of the required thickness by the use of long, thin chisels, that resemble knives. The thickness of the slabs is determined by their use; slate designed for roofing houses is from one-eighth to one-sixth of an inch, while that designed for mantels and wainscoting is from one-half to three-fourths of an inch in thickness.

The most extensive use of slate is in roofing buildings. It can be split into slabs as thin as shingles, resists all action of the weather, and is a protection against fire. These qualities combined with cheapness make it one of the most desirable coverings for a roof. The size of the slate for roofing depends upon the place where it is to be used. That intended for the roof of a small house is smaller than that designed for large buildings. There are two reasons for this; the small size looks better on the small roof, and can be made from slate that will not work up into the larger pieces.

A slate shingle, if we wish to call it by that name, is rectangular in form, and about once and

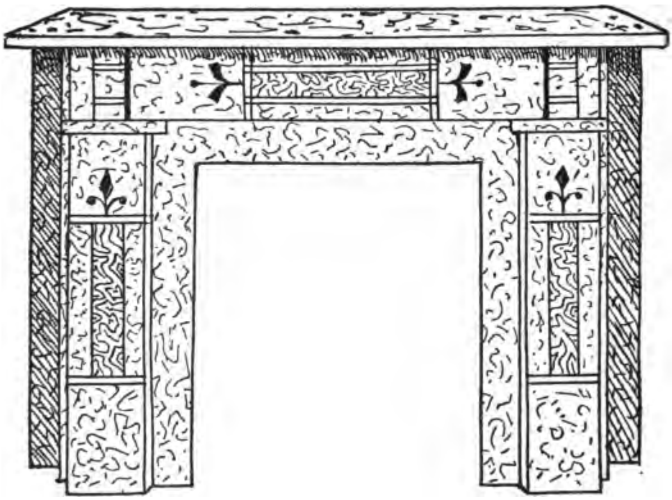
a half as long as wide. It is first split from the larger block, then trimmed by the workmen to the required form. This is done by placing the slate on a T shaped piece of iron called the anvil and striking it lightly with a slater's hammer. One end of this hammer is shaped something like a hatchet, and the other is brought to a sharp point. After the workman has trimmed the edges, he turns his hammer, and punches two holes in the piece for the nails. Sometimes triangular or hexagonal forms are cut for trimmings. No finishing of the surface is necessary as the cleavage leaves it smooth enough for roofing.

The slate is laid in courses like shingles, and a slate roof resembles a shingle roof very closely; the principal difference being in the color. By combining slate of different colors beautiful designs are sometimes made on roofs where ornamental work is desired.

Slate is the best material for blackboards, and is extensively used in finishing school houses. For this purpose the slabs are split about one-half an inch thick, and cut four feet wide and from four to six feet long. The cutting is done with circular saws, the same as those used in sawing lumber, but the saws do not run as rapidly. The ends are finished so the slabs will make perfect joints when placed on the wall, and the surface is either

finished on a rubbing bed or by hand. The hand finished boards are much nicer than the others. Some times rough places are found, and are caused by hard places in the slate.

You may have seen mantels that you thought were marble, only you wonder where stone of such a color was found. Most of such marbles are



slate. Mantels are made of wood, marble, iron and slate. Those made of wood shrink in a short time and leave ugly cracks in the finish; those of iron are liable to lose their enamel; those of marble are very beautiful if they harmonize with the finishing of the room, but they cannot always do this. Slate mantels have some advantage over

all these others. They are cheap and durable, and can be finished in any color and style desired, but you must not think a slate mantel nicer than one made from marble.

The mantel is first shaped and carved, and the pieces made as smooth as possible; they are then coated with a varnish paint that forms the background for the finish. When this coating is dry the finish which produces the marble appearance is put on. This finish is of oil paint and applied in the following manner: The paint is spread on the surface of water in a tank and the slab dipped. The paint takes all sorts of fantastic forms, and by mixing two or three colors almost any style of marble can be imitated. On account of this appearance the process is called marbleizing, and the finished stone marbleized slate. After dipping, the slabs are baked in a kiln for ten or twelve hours; this hardens the paint so it takes a high polish when rubbed down. The beautiful mottled appearance sometimes seen on panels is produced by the use of water colors. The light color is spread evenly over the dark background, and then partially lifted with a sponge. The sponge also blends the colors enough to make them resemble the natural colors seen in some kinds of stone.

The material used in marbleizing slate is varnish paint, oil paint and water color. The varnish

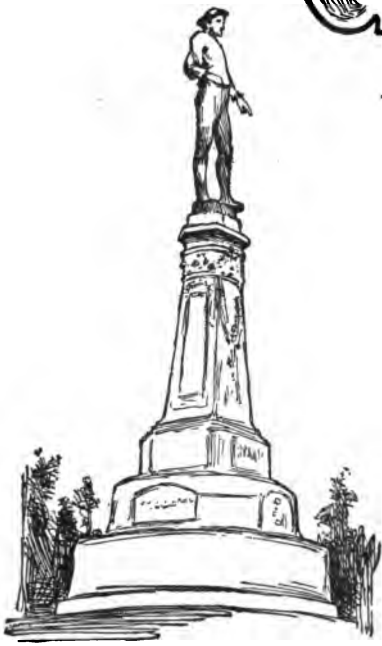
paint is so mixed that it dries quickly and holds its color well. The skill consists in mixing and spreading the paint so as to produce the desired effect.

Plain slate is used for sinks, laundry tubs, mop-boards, steps, landings to stairways and for many other purposes about houses. It will not absorb water, and withstands all acid or other corrosive liquids, so is valuable where a material that resists their action is needed.

In former times slate was use for headstones, and in the oldest cemeteries in New England these stones may still be seen. They are elaborately carved, and every line can be traced on them although they have been exposed to the weather for more than a hundred years.

The softest varieties of slate are used in making pencils. The stone is sawed into blocks seven inches long and six wide. These blocks are split into slabs a little more than a quarter of an inch thick, and the slabs run through a series of grooved knives which cut them into pencils. The pencils are packed in boxes which hold a hundred each, and are shipped in cases of a hundred boxes. The waste is ground into flour which is used in making pencils that are encased in wood. If you have used these pencils you know that they are much the best.

GOLD AND SILVER.



MARSHALL MOUMENT AT COLOMA.

GOLD and silver are known as precious metals on account of their scarcity and great value. These metals are very generally distributed over the earth, and are usually found together or in the same locality. Gold, being less abundant, is far the more valuable.

Gold and silver are not only found together, but are subject to the same treatment to extract them from their ores, they have many properties in common, and are extensively used for the same purposes. For these reasons

we speak of them together. Silver is the whitest of all metals, and gold is the only yellow metal known. Pure silver always has the same color, but the shade of gold varies in different locatities. Both have been known from remotest antiquity.

Gold was used by the Egyptians as far back as we can learn anything of their history. It has been found in the tombs of the Pharaohs, and was wrought into gold cloth and many fantastic forms by their smiths. When Pharaoh made Joseph ruler over the country he put a chain of gold about his neck and a ring upon his hand. When the Israelites escaped from bondage they carried great quantities of gold with them, a portion of which was used in the construction of the Tabernacle.

The Babylonians and Assyrians were also acquainted with the metal, and their smiths worked it with great skill. We read of the gold from Ophir in the days of Solomon, and wonder at the amount used in adorning the great Temple at Jerusalem. The Greeks and Romans were early acquainted with both gold and silver, and from their day to the present both metals have been in use among all civilized people.

Perhaps the most wonderful skill manifested in the use of gold and silver by partially civilized nations was found in Mexico and Peru when those countries were conquered by the Spaniards. Both

the amount of these metals and the skill displayed in manufacturing them into implements and ornaments surpassed anything the conquerors had ever seen or heard of. The metals were not used for money, but for the sacred vessels in their temples of worship, and to adorn the palaces of the emperor and nobility.

When Cortez invaded Mexico, the Aztec monarch sent an embassy to meet him. These ministers brought with them many valuable and curious presents, among which were shields, helmets, and breast-plates embossed with plates and ornaments of pure gold. They also presented the Spaniards with a helmet full of gold dust and many ornaments in the imitation of birds and animals wrought with great skill from gold and silver. In addition to all this they gave them two plates of gold and silver as large as carriage wheels. One of these wheels measured fifteen feet in circumference, and was valued by the Spaniards at $230,000. On their march into the country, Cortez and his followers found vases of silver so large that a man could not reach around them. These vases were elaborately carved with the figures of birds, flowers, and animals.

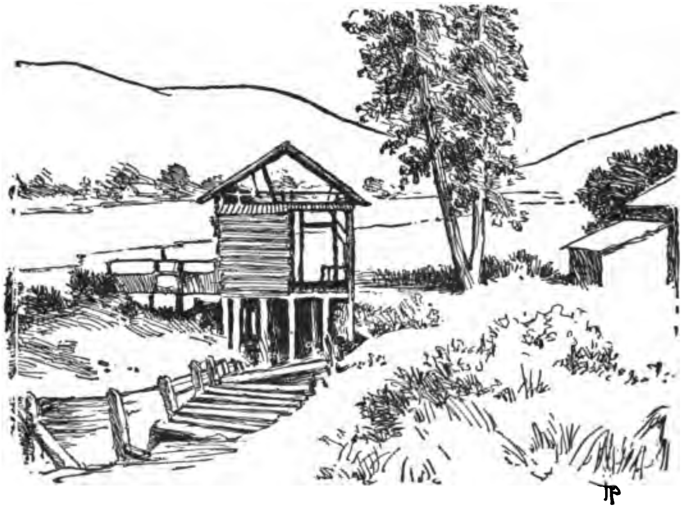
But wonderful as the riches of the Aztecs may seem, they were far surpassed by those of the Incas whom Pizarro found in Peru. The great

temple at Cuzco was literally a mine of gold. On the wall facing the eastern portal was a plate of gold representing the sun with rays extending in all directions, and so large that it covered nearly the entire wall. The other walls were also richly ornamented with the same precious metal, and a frieze of gold extended around the building on the outside. Another chapel dedicated to the moon was equally gorgeous in its decorations of silver. This metal was so abundant that the Spaniards used it instead of iron to shoe their horses with.

When Pizarro captured and imprisoned the emperor, he told his captors, that, if they would give him his liberty he would cover the floor of the room in which he was confined with gold. As the Spaniards hesitated, the emperor reached up as high as he could, and made a mark on the wall. He then told Pizarro that he would fill the room with gold and silver as high as that mark if he would let him go. The room was 22 feet long and 17 feet wide. The conditions were that the articles should be placed in the room just as received and that the Inca should have two months in which to collect the treasure. The messengers were dispatched, and the gold began to come in. A short time before the task was completed, the wicked Spaniards put the emperor to death and plundered the entire country. Never before nor since

was such a quantity of gold collected in one place as these Incas gathered for their cruel conquerors.

Gold has been mined in the mountainous regions of Europe and Asia for centuries. The mines in



SUTTER'S MILL.

Spain, Russia and Siberia have been the most noted in recent years. But the greatest quantity of both gold and silver have been produced in the United States and Australia, which country has been especially rich in gold. Valuable mines have been recently opened in South Africa, and some think this is the famous Ophir of Solomon's day, and the land from which he obtained most of the gold used in the magnificent buildings which he erected.

The discovery of gold in California was one of the most important events in the history of modern times, because it has done so much towards developing that portion of the country west of the Rocky Mountains, and because it has had such influence on the commerce of the world.

The Spaniards who went north from Mexico, found a little gold in the southern part of California, and worked the river beds to a limited extent before the territory became a part of the United States. The amount of gold taken was small, and the miners kept their secret, so no one knew of its existence.

Like many important events, this great discovery was made by accident. At the close of the Mexican War there were a few American settlers in California. Among these was Captain John A. Sutter, a Swiss by parentage. Captain Sutter made a settlement at the junction of the Sacramento and American Rivers, near the present city of Sacramento. The location was important as it was at the same time at the head of navigation on the Sacramento, and the first station on the overland route across the Rocky Mountains. The settlement was named New Helvetia, but it is more commonly known as Sutter's Fort. The number of travelers passing the fort made it necessary for Captain Sutter to erect a grist mill that he might

be able to provide proper food for his guests. The construction of this mill made it necessary to construct a sawmill also. As there was no timber near the fort, it was decided to build the sawmill further up the American River.

There was at the time a man in Sutters' employ who was destined to link his name forever with the history of California. This man was James W. Marshall, a native of New Jersey, and a millwright by trade. Captain Sutter engaged Marshall to go up the river, select a suitable site, and erect a sawmill. The site was selected at what is now Coloma, about sixty miles from the fort, and a dam and millrace were constructed. At night Marshall would let the water into the millrace that it might remove the loose gravel and clear it up for the next day's work. On the morning of January 24th, 1848, as Marshall was examining the race while the water was turned off, he discovered some small particles of a yellow shining substance on the rock which formed the bottom of the ditch. He picked them up and noticed they were about the size of grains of wheat. He said that his heart gave a great thump for he thought they were gold.

However, as he thought the matter over, he remembered that a substance called iron pyrite resembled gold so closely that it was often mistaken for it, and his specimens might be only

pyrite. He proceeded to hammer them, and found they were malleable. As pyrite was very brittle, he knew they were not of that substance. Marshall showed his specimens to his companions and jokingly told them he had found a gold mine. During that day and the next more gold was found, but the gold mine was considered only a fit subject for ridicule, and no special attention was paid to the matter by the men. Marshall regarded it more seriously, and took the first opportunity to determine what his specimens were.

Marshall's experience with gold had been confined to gold coin, which had a reddish tint. He could not make the yellow of his specimens agree with that color. In a few days he had occasion to go to the fort for supplies, and took his gold along to test it. Captain Sutter had a cyclopœdia which gave a description of all the metals, and with this to guide them, and a balance and some sulphuric acid, they made a thorough test of the specimens, which proved to be pure gold. They decided to keep their discovery secret for the time, lest the men at the mill should all leave their work and take to hunting gold.

Work went on at the mill as usual. A little gold was found every day, but no special attention was given it. In the spring several men began gold washing as a regular occupation on a small

island in the American River, a little below Coloma. By the use of pans and Indian baskets they secured about $40 worth a day to each man. In the middle of June one of the two San Francisco papers came out with an article headed "*Gold!* GOLD!! GOLD!!!" As the result of this publication, men flocked to the Coloma Valley. Workshops, dwellings, families, and even fields of grain ready for harvest, were left to take care of themselves.

The method was so simple, and the necessary tools so few and inexpensive that neither capital nor skill were needed by the would-be miner. All that was needed to secure the coveted treasure was to wash it out of the gravel. As gold is nearly twenty times heavier than water, this could be easily accomplished. The gravel was placed in a pan with water and vigorously stirred; the gold quickly settled to the bottom and the gravel was poured off with the water. A few washings would leave the gold clean. A pan, pick, and shovel were all the tools needed. If the gravel paid 25 cents a pan, the miner would make $15 a day; it often yielded much more than this. There are authentic accounts of a single man's taking $1,000, and even $5,000, as the result of one day's washings. In 1849 any claim that did not yield at least $16 a day was abandoned as not worth working. The land, which was owned by the government,

was preempted by the miners without even the asking, and claims were regulated by mutual agreement among themselves. Truly men had found the fabled El Dorado where gold in abundance could be had for the gathering.

Fortunately the fields proved to be ample in extent and wealth to meet the demands of all who came. The region opened around Coloma was explored until it was found to embrace a territory 200 miles long and 30 wide. About two-thirds of this lies to the north of Coloma, and beyond the large gold area are two smaller areas. But from the great gold field of California most of the gold has been taken, and here nearly all the improvements in methods and machinery for mining have been discovered and invented.

The effect of the discovery of gold in California is almost beyond our comprehension. Up to 1847, the entire yearly product of all the gold mines of the world was less than $25,000,000. The gold mined in California in 1848 amounted to $5,000,000, in 1849 it was $23,000,000, in 1850 it was $50,000,000, and in 1853 it amounted to $63,000,000, then it began to decline. At present the yearly production is about $15,700,000.

Never was such treasure known before; all the glittering accounts of precious metals stored up by the nations of the East in past ages, or wrested

from the empires of Mexico and Peru by their cruel

THE CRADLE.

conquerors were not to be compared to the wealth which the barren fields of California yielded to the American miner.

There were about 2,000 American settlers in California when gold was discovered. San Francisco was a village of 700 inhabitants and had two small newspapers. The reports of the discovery began to reach the Atlantic states in the fall of 1848, but were generally disbelieved. In January and the following months large amounts of gold reached Panama and New York. In the spring a rush was made for California. Nearly 50,000 people from the United States and 40,000 from other parts of the world emigrated to the territory in a single year. This discovery placed lines of steamships on the Pacific, and opened the ports of South America and China and Japan to commerce; it was the direct cause of the first emigration of Chinese to the United States; it built the Panama Railroad and linked ocean to ocean.

This discovery of gold changed California from a Spanish to an American state; settlers continued to pour in each year until a large population had taken possession of the territory, and discovered in the fertility of the soil and the salubrity of climate a source of wealth far greater than that of the gold mines. California is now one of the richest states in the Union. In 1889 she produced three times as much gold and four times as much silver as any other state, and San Francisco is the ninth city in size. The only means of crossing the con-

tinent in 1848 was by a single wagon trail over the mountains; now five lines of railway within the boundaries of the United States connect ocean with ocean. Large cities have sprung up in all the states of the Pacific slope, and that section of country has a sufficient population to constitute a respectable nation.

Mr. John S. Hittell, speaking of this great discovery, sums up its importance as follows:

"Marshall's find did not limit its great influence to our continent. It aroused and stimulated industrial activity in all the leading nations. It profoundly agitated all the countries of South America. It shook Europe and Asia. It caused the first large migration of Chinese across the Pacific. It opened Japan to the traffic of christendom. It threw a belt of steam around the globe. It educated Hargraves, and taught him where to find and how to open up the gold deposits of Australia. It built the Panama railroad. It brought the Pacific ocean within the domain of commerce. Directly and indirectly it added $3,500,000,000 to the stock of the precious metals, and giving the distribution of this vast sum to the English-speaking nations added much to their intellectual and industrial influence."

But what of the effect upon those who were immediately connected with it? Marshall died in

poverty and want, and lies buried in sight of the spot where he picked the first grains of gold from the millrace. Sutter lost all his property, was pensioned by the state, and died a poor man. None

THE SLUICE.

of the early miners, who gathered fabulous amounts of gold from the mines, became wealthy men, and most of them spent the latter part of their lives in want and toil. Like many since, they disregarded the lessons of thrift and industry and spent their earnings foolishly.

"Riches, like insects, while concealed they lie,
Wait but for wings, and in their season fly;
To whom can riches give repute or trust,
Content or pleasure, but the good and just."

MINING.

Gold occurs in grains and nuggets as free gold and in lodes or veins of quartz as ore. Most of the ore contains silver mixed with the gold, and sometimes other metals are also found. The gold of the river beds and gravel banks is free and usually pure. Most of the pieces are very small and resemble fine sand. Now and then a nugget is found as large as a pea or bean. The early miner in California had his leather pouch and balance, and when making purchases weighed out the necessary amount of gold to pay the bill. A few large nuggets have been found, the largest being that of Australia, and weighing 184 pounds, 8 ounces, Troy, and worth over $41,000.

All metals were once in a molten state in the earth's crust, and when they cooled collected in masses. This is the way gold accumulated in the rocks. As the rocks decayed and were washed down into the valleys, the particles of gold went with them, so all the gold now found in the gravel was once in the solid rock. These conditions made

it possible for every one to mine for himself in the early history of gold digging. When the rainy season flooded the river bottoms, the miners searched for gold in the gravel of the river banks and on the hillsides and mountains. Their search was well rewarded, for they found plenty of "pay dirt," as they termed the gold bearing gravel, and also discovered many gold bearing veins of quartz.

All devices of the placer miner are for the purpose of separating the gold from the gravel. The simplest and earliest of these was the common pan which has already been described. This worked well, but the miner could wash only a little gravel at a time, and his earnings were proportionally small. The pan was followed by the rocker or cradle, so called from its resemblance to an infant's cradle. By means of the rocker a much larger quantity of gravel could be worked. The long-tom followed the rocker, and was an improvement over it, as it enabled the miner to wash still more gravel. The long-tom is usually twelve feet long and twenty inches wide in the upper part and thirty in the lower. It is shaped like the cradle and is inclined so a strong current of water will run through it. Gravel is shoveled in at the upper end where a stream of water is admitted. At the lower end is an inclined riffle of punched sheet iron. As the gravel passes over this,

the gold falls through the holes into a box beneath.

All of these machines allow more or less of the gold to escape, and as the richest placers became exhausted, devices for saving this waste were in-

MONITOR.

vented. The miner soon learned the use of quicksilver, and employed it wherever it could be of service. This metal, which we see in most of our thermometers, is liquid at ordinary temperatures. It dissolves gold and silver as readily as water dissolves sugar. The compound formed is called an

amalgam. By mixing quicksilver with the gravel, or placing it in the riffles of the long-tom it would catch all the particles of gold that were likely to escape. The quicksilver was easily removed from the amalgam by distillation. The employment of this process enabled the miner to secure larger returns for his labor, and to work gravel that before would not have paid for handling.

Finally the small placer diggings became exhausted, and mining on a small scale was no longer profitable. Capital and engineering skill were necessary, and this led to the formation of companies and the construction of extensive works. The original miners became the employes of the companies, and settled down to a more home-like life. The sluice took the place of the long-tom, and the eroding force of water that of the pick and shovel. This is called the hydraulic method.

The discovery of gold scattered through the deep deposits of gravel in the canons and on the mountains led to the employment of water for dislodging these deposits. The first hydraulic apparatus was a very crude affair. From a small ditch on the hillside, a flume was built towards the ravine where the mine was located. The flume gained height as it neared the ravine until a fall of forty feet was reached. At this point the water was discharged into a barrel from the bottom of

which a hose extended downward to the mine. The hose was six inches in diameter, and was made of common cowhide. Attached to the lower end of the hose was a tin nozzle four feet long, and tapering to an opening one inch in diameter. This simple machine worked so well that other miners soon adopted it, and from this small beginning the great system of hydraulic mining has been built up.

A dam is constructed high up in the mountains, and a flume leads from this down to the gravel bed. These flumes were at first constructed of wood, but strong iron pipes are now used. The water is confined so the pressure of the entire fall is brought to bear on the gravel to be washed. The nozzles of these large pipes are call monitors, and resemble a huge cannon. They are perfectly balanced and attached to the pipe by a movable joint so they can be turned in any direction by the operator. The stream is frequently a foot or more in diameter, and has a pressure of 250 or 400 feet of fall. So great is the power that the water will move rocks weighing tons as though they were mere pebbles.

As the economy of working this system depends largely upon the amount of gravel that can be moved with a given quantity of water, blasting is often resorted to for loosening the gravel before the water is turned on. The sluices receive the

gravel as it is washed from the bank and take the gold from it in a manner similar to that of the long-tom. The bottom of the sluice is lined with stone or wooden blocks like those used in paving streets. Pockets are frequently left in this lining, and these with a free use of quicksilver take up the gold. Most of the metal is caught in the upper part of the sluice, and these pockets have to be frequently cleaned. "Under currents," which are broad sluices with a slower current, are frequently placed under the main sluice. The water from the upper half of the stream falls into these under currents, and allows the fine particles of gold and amalgam which would be carried to the dump by the swifter current to settle. The more under currents used the more complete the extraction of the gold.

Hydraulic mining has been extensively carried on in California for a number of years, and has proved very profitable, notwithstanding the great expense of constructing dams and flumes. But many of the best placer mines are located in portions of the state that contain excellent farming lands and which have been thickly settled. Flooding the streams with so much water and gravel caused overflows which deposited the gravel on the rich soil of the meadows and destroyed their fertility. The owners of the land naturally objected to

this, and appealed to the United States courts. The courts sustained the farmers, so hydraulic mining is now restricted to those localities where it cannot injure the land.

The deep mines are located in the mountainous regions, and are most extensively worked in California, Nevada, Colorado, Montana, and South Dakota. Nearly all the states in the region of the Rocky Mountains have gold and silver mines, and a few in the region traversed by the Appalachian system have gold mines. The mines of the Apalachian country are not as extensive or as profitable, however, as the others. As gold and silver are invariably found combined in these ores, the description and method of treatment of one will answer for all.

The metals are found to be very irregularly scattered through veins of quartz which are often narrow and inclosed with rock of a different kind. It is the object of the miner to remove the ore at the least expense, so only enough of the surrounding rock is loosened to enable the men to work. As the vein is often crooked and irregular, the galleries become very intricate. Some of these mines are also very deep. The celebrated Comstock Lode of Nevada is over 3,000 feet in depth, and the temperature is so high that it is difficult to work in the deepest galleries. This mine contains over

185 miles of galleries, and in twenty-one years produced over $306,000,000 worth of bullion, of which $132,000,000 were gold.

ALASKA GOLDFIELDS.

In 1896, gold was discovered in Alaska in the region of the Klondike River. Here the gold is in free, large grains and the deposit is extremely rich, but mining operations are seriously hindered by the long and cold winters. The three months of the summer season is the limit of out door work. When the world at large learned of the rich mines of the Klondike region, thousands of people rushed there. Only a few of these obtained the riches they sought; all suffered severely, and most returned penniless. Gold was found near Cape Nome on the coast of Alaska, a little south of Behring Strait, in the summer of 1898. The news of the find was quickly noised abroad, and in the fall and winter many thousands came across the snow and ice to stake out claims. The mines of this region produced about $2,000,000 worth of gold in 1899 and about $7,000,000 worth in 1901.

Perhaps no better example of the remarkable energy of the American people has ever been given than the building and growth of the city of Nome, which became the center for the outfitting of all prospecting parties in this district. Among the number who reached Nome were many merchants,

traders, and professional folk. In less than a year they built a town with accommodations for over ten thousand people.

REDUCTION OF THE ORE.

The treatment of the ore depends upon the substances combined with the metals. Sulphur is always present and forms compounds known as sulphides and sulphurets. The extraction of the gold and silver from many of these ores is very difficult, and it is only within a few years that processes have been discovered that enable them to be worked with profit. A low grade ore yields from $3.50 to $8.00 a ton, a high grade yields more than this. In low grade ore the gold can seldom be seen, and one unacquainted with it would not consider it of any special value. Still ores of this nature often yield greater profit than those in which specimens of free gold are found. The silver bearing ores usually contain lead, copper, and every known silver mineral. Such ores are called refractory, and it is necessary to roast most of them.

When the ore comes from the mine it is dumped over "grizzlies." These are screens made of iron bars set at such an angle as will allow the ore to slide over them; in its passage, the small pieces fall between the bars into a bin and the large ones

are carried to the rock breakers. After being reduced to suitable size they are also sent to the bin. From the bin the ore goes to the driers where most of the moisture is driven out; it is then dumped upon a floor and taken to the furnaces to be roasted. Salt is mixed with it before roasting; the heat sets chlorine free from the salt, and this combines with the compounds in the ore to form chlorides from which the gold and silver can be obtained. It is then taken to the hoppers that feed it to the stamp mills where it is crushed.

The stamp mill consists of a strong iron trough called the mortar, into which the stamps fall. The stamps are attached to the ends of heavy iron bars which are elevated by a cam on a revolving shaft. The stamp falls of its own weight and crushes the ore almost to a powder. As the ore is crushed it is driven out of the mortar through wire screens placed in its side. Five stamps are usually operated by the same shaft; this arrangement is called a battery.

The pulp, as the crushed ore is called, now passes to the pan room. The pans are really revolving tanks that hold about 3,000 pounds each. The pulp is here treated with quicksilver and heated with steam to hasten the action. The amalgam is run to large tubs filled with water, where it is allowed to settle, and the sand is poured off with

the water. As it leaves the tub the sand passes through an agitator which arrests any amalgam that it may contain. The amalgam is then placed in retorts and the quicksilver removed by distillation. The gold is then melted and run into bars, and is known as bullion.

Another method, known as the Plattner process, differs from that described in that it treats the ore to chlorine after crushing, and dissolves the chloride by leaching it out of the pulp. The chloride is then allowed to settle in vats to which it has been run. It is then treated with sulphuric acid and salt to remove any compounds of iron it may contain, after which it is dried and smelted in cast iron retorts. The gold obtained by this process is nearly pure and about ninety-five hundredths of what the ore contains is extracted.

Ores treated by the Plattner process contain silver, and this is recovered after the gold is leached out, as the chlorine does not act on the silver in the compound. The leached ore is treated to a preparation of lime which forms a sulphide of silver, and from this the pure metal is easily obtained. When silver occurs with lead the metals are easily separated by smelting in a furnace which has a layer of ashes on the bottom or hearth. The lead melts at a much lower temperature than the silver and is absorbed, leaving the silver pure.

PROPERTIES AND USES.

Pure gold is bright yellow and has a high luster; it is nearly as soft as lead, and has to be hardened by mixing some other metal with it before it can be used; it resists the action of the air and all acids except a combination of muriatic and nitric acids which dissolves it, forming gold chloride; it is the most ductile and malleable of all metals, and can be drawn into wire finer than a silk thread and hammered into sheets so thin that 150,000 of them will not exceed an inch in thickness, or one ounce of it will cover a hundred square feet of surface.

A mixture of gold or silver with a cheaper metal is called an alloy. Gold is alloyed with silver and copper, and silver is alloyed with copper to fit it for use. We usually determine the proportion of gold in any article of jewelry by the number of carats fine stamped upon it A carat is one twenty-fourth, and gold marked 22 carats fine—jewelers' standard—is 22 parts pure gold and two parts alloy, which is usually silver and copper. If the silver is used alone, it gives a lighter color to the metal, but with the combination the natural color of the gold is maintained.

Silver is pure white, and almost as soft as gold.

It occasionally occurs free in the form of beautiful crystals, but is generally found in ore in the form of a sulphide or chloride. Silver ore is usually dark gray, and sometimes almost black, and has no resemblance to the beautiful metal obtained from it. Silver is nearly as ductile as gold, and some claim it to be even more malleable; it is alloyed with copper to harden it, the proportion of copper depending upon the use.

In general the uses of these metals are similar; we find them in ornaments, as jewelry, vases, and plate; in many kinds of table ware; and in the coins of all civilized nations. Gold leaf is used by the dentist in filling teeth, and both gold and silver leaf by the painter and decorator. By combining copper and other metals with gold and silver in different proportions leaves of a great variety of colors can be made, and the finest bronzing is of this material.

Certain compounds of silver are very sensitive to light, and change their nature or color when exposed to it. This principle is the basis of photography, and all the beautiful pictures produced by this art are due to silver.

COINAGE.

The word coin originally meant stamp, and was the name given the stamp used in preparing a

piece of metal for money. The name has now passed from the tool to the metal receiving the impression, so coin means a piece of metal stamped with its value and the imprint of the government issuing it for money; coin is money. Coinage is of great antiquity, and is supposed to have been invented 800 B. C.; but the use of gold and silver as money must have been from a time long before this. We read in Genesis that Abraham returned from Egypt "very rich in cattle, and silver, and gold"; and in his purchase of the cave of Machpelah, he weighed out the price agreed upon, "400 sheckels of silver, current money with the merchant." This was nearly 2,000 years before Christ.

Many coins now in perfect state of preservation date back hundreds of years before the Christian era, and are metallic monuments of their time and nation, as they bear the portraits and names of the great heroes of the age in which they were made. In the early history of the colonies, each issued coin of small value to meet its needs. At the close of the Revolutionary war Congress took measures to secure a national system of coinage. In 1785 a plan presented by Thomas Jefferson was adopted. This is the basis of our national system of money, and is one of the many benefits which this great statesman conferred upon his country.

The dollar is the unit of the American money system, and is based upon the value of a given weight of gold. For United States coin the standard is nine parts pure metal to one part alloy; the alloy for gold is nine parts silver to one part copper. Twenty-five and eight-tenths grains of gold constitute a dollar, and the weight of all gold coin is based upon this standard. The original gold dollar was about the size of a silver five-cent piece, and was inconvenient to carry on account of its small size; for this reason its coinage has been stopped for several years, and these coins are now very scarce.

The size of silver coins was regulated by the gold dollar and the relative value of the two metals. The ratio which has been longest in use is that of 16 to 1; that is considering gold 16 times as valuable as silver. This gives us a silver dollar of four-hundred twelve and one-half grains. This standard was adopted when silver was much more scarce than it is now, and the increase in quantity and change in value of this metal, has led some to consider the advisability of adopting another ratio.

The place where money is coined is called the mint. The first mint in the United States was established at Philadelphia in 1792. There are others at San Francisco, Carson City, Denver, and

New Orleans, but that at Philadelphia is the most important.

Coining is an interesting process. The metal is first prepared so it is sure to be of the standard required by law. It is then rolled into ribbons of the required thickness of the coin. From these ribbons the pieces are punched for the coin; these pieces are called planchets. The planchets are carefully weighed to ascertain their value; if too light they are cast aside to be re-melted, if too heavy they are filed around the edges until of the proper weight. They are then taken to the milling machine, where the edges are milled; from here they go to the stamping machine which finishes them. Both sides are stamped at once by means of steel dies in a press having a powerful leverage. This press works rapidly, and can coin dollars almost as fast as a boy can count them. After the coins have been carefully examined to see that no imperfect ones are among them they are ready for circulation, and start on their journey through the world.

COPPER AND ZINC.

In the eastern part of the Mediterranean Sea is situated a large island called Cyprus. Here many centuries ago the Romans were accustomed to mine a bright red metal, which they named Cuprum, from the name of the island. To-day we call this same metal copper. This incident shows that copper was known to the Romans, who used it in a pure state for coin, and when alloyed with tin, for shields, armor plates and statues.

But copper was known as a useful metal long before the time of the Romans. We are told that Cheops, the builder of the great pyramids in Egypt, worked a copper mine in the Sinai peninsula, and that the Egyptians had a process of hardening copper so that they could make out of it tools for cutting stone and other hard substances. Many copper utensils have been discovered among the ruins of ancient Babylon, and in the book of Job, which some scholars believe to be the oldest book of the Bible, we read that "copper was molten out of stone."

Copper was used by the native races of America long before this continent was discovered by white men. When the Spaniards conquered Mexico in 1521 they found the Aztecs using axes and other

tools made of copper, and the Incas of Peru were found in possession of similar implements a few years later. Both nations had large copper mines in their countries, which they worked with success.

Copper, like gold, is found pure in some localities, were it occurs in veins and pockets in the surrounding rock. This is called native copper, and is the source of about one-fourth of the supply produced in the United States. The larger amount is, however, extracted from ores, most of which are compounds of copper and sulphur, or copper and carbon dioxide. The latter form carbonates of copper, and are among the most beautiful rocks known. One variety, called azurite, is a beautiful blue crystal suitable for ornaments, but it is not found in sufficiently large quantities to make it a source of copper. The other carbonate is called malachite. It has a mottled green appearance and is hard enough to take a polish like marble. Malachite is extensively quarried in the Ural mountains, and is used in making mantels, table tops, and many smaller ornamental articles, such as matchsafes, inkstands and the like. When polished it is very beautiful, and objects made from it are so expensive as to place them above the means of any but the wealthy. Inkstands of malachite often cost from $16 to $20, and table tops sometimes are valued as high as $2000. It is needless to say that the best quality

of malachite is not used in the production of copper, as it is much more valuable for other purposes. A number of carbonates of inferior quality, however, constitute an important source from which copper is obtained.

The compounds of copper and sulphur form the most abundant ores. These are easily recognized by their brass-like color and metallic luster. This ore is often known as yellow copper and copper pyrites. It is very brittle and often so soft that it can be cut with a knife. Another variety, containing more sulphur and called copper glance, is also an important source of supply. Sometimes iron is combined with the copper in these sulphur ores, and when this occurs the rock reflects various tints of purple and is called peacock copper or horse-flesh ore.

COPPER MINES.

While copper is very generally distributed over the earth, it occurs in large quantities in only a few localities. In Europe there are several important mines in Spain, which have been worked for centuries; others are found in the Ural mountains in Russia, and others in Norway and Sweden, Saxony, France, and in Cornwall and Devonshire, England.

However interesting it might be to learn the history of the copper mines of other countries, we are

more particularly interested in those at home, both because they are connected with the industrial development of our country, and because they are the largest in the world. The great copper mines of the United States are located in Michigan, Montana and Arizona. Considerable copper is obtained from the gold and silver mines of Colorado and California, in connection with the smelting of these ores, and small mines are also found in a few states through which the Appalachian mountains pass, but the three states first named produce nearly all the copper mined in the country.

If you look on the map of Michigan, you will see a small point of land projecting into Lake Superior from about the middle of its south shore. This is Keewenaw Point; it is a little more than 60 miles long and about 20 wide in its widest place. On this point are located the most interesting copper mines in the world.

The mines on Keewenaw Point have been worked since 1845, and from 1874 to 1883 they supplied more than one-half the copper produced in the United States. The metal occurs as native and is found in veins and pockets inclosed in a brown sandstone. Occasionally the most beautiful crystals are found encased in a pure milk-white quartz. These are highly prized for cabinet specimens. There are six large mines now in operation, and

one of them, the Calumet-Hecla, has obtained a world-wide reputation on account of its great value and the extent of its operations. The miners have been constantly seeking lower levels, and now the

UNDERGROUND IN THE CALUMET AND HECKLA MINE.

main shaft has a vertical descent of more than 6,000 feet, by far the deepest in the world.

The operation of these mines requires the most powerful machinery that can be constructed for such purposes, and the city of Calumet, which has

been built up around the shafts, is a city of tall chimneys and large engines, used in ventilating the mines, pumping out the water and hoisting the ore. Since a full description of how all this is done has been given in describing the operation of a coal mine, we do not need to repeat it here.

The Montana mines are located at Butte and at Anaconda, which like Calumet are mining cities. These mines are more like quarries and are not noted for their depth. The ore is copper pyrite, copper glance and peacock copper, and occurs in granite. The Montana mines have been developed within the last few years and now produce the largest amount of copper of any in the country. The Arizona mines are located in the southwestern part of the territory in the Clifton, Bisbee and Globe districts. The ore is either a carbonate or an oxide. These mines have been worked since 1883 and now produce about one-fourth of the output of the country.

SMELTING.

The method of treating copper ore depends upon its composition. Where the ore contains only native copper, like that of the Lake Superior region, the treatment is very simple. The ore is crushed in heavy stamp mills, and the copper separated by washing. The crude metal is then sent to the smelters, melted and run into ingots, which are

ready for shipment. Since copper is smelted without difficulty, no such elaborate furnaces are required as in the reduction of iron ore.

Ores containing sulphur are subjected to a complex treatment. Usually the ore is broken into

SMELTING WORKS—LAKE LINDEN.

pieces about the size of anthracite coal used in stoves. It is then roasted to expel the sulphur, which passes off in the form of gas. As the sulphurous gas kills all vegetation which it touches, regions near the smelting works present a desolate

appearance. After being roasted the ore is melted, producing "matte," a compound of copper, sulphur and whatever other metals the ore may contain, but having from 50 to 65 per cent of copper. The matte is usually remelted and placed in Bessemer converters, where the sulphur and arsenic, if present, are expelled by a process similar to that used in making Bessemer steel. and explained on pages 98 and 99.

The result of this process is usually an alloy of gold, silver and copper. The alloy is now dissolved in acid and the solution treated with a powerful electric current. The pure copper collects around one wire conveying the current, and known as the negative pole, and the gold and silver settle on the bottom of the vessel as a brown mud, from which they are separated by processes like those already described in explaining how silver is obtained from its ore. The gold and silver obtained are often sufficient to pay the entire expense of mining and smelting, so that all received from the sale of the copper is clear profit.

PROPERTIES AND USES.

Copper has a peculiar red color and a disagreeable odor. When exposed to the air it oxidizes and turns brown, but this does not seem to work any injury to the metal. It is about nine times as heavy as water, and among the common metals

ranks next to iron in hardness and strength. Copper is very ductile and malleable; that is, it can be drawn into very fine wire and rolled or hammered into very thin sheets. A wire one-thirteenth of an inch in diameter will sustain a weight of 300 pounds. Next to silver, copper is the best known conductor of electricity; it is also one of the best conductors of heat. When taken into the system it is one of the most fatal poisons.

The uses of copper are many, and they are being constantly extended. During the last quarter of the nineteeth century the application of electricity to so many purposes created such a demand for copper as to greatly advance the price. The use of electric lights; the use of so many telephone lines, the replacing of steam engines by electric dynamos in factories, and the construction of so many electric railways have all required an amount of copper so large that we can not estimate it. We can understand something of what this means when we remember that the telephone wires in the United States have a combined weight of more than a half-million tons.

Copper nails and bolts are used in the building of ships and copper plates are used to sheathe the hulls, because the metal does not corrode from the action of the water, and copper keels are always smooth. Another important use of the pure metal is in making electro-plates for printing, and thereby so reducing the price of books that they are no longer considered as luxuries. If you wish to know how this is done see "Great American Industries," Volume III, page 180. Pure copper has

also been used for coin ever since money was known, and is still in use for small coins among most civilized peoples.

The alloys of copper are very numerous, and their manufacture consumes more of the metal than is used for any other purpose excepting the making of copper wire. Brass is made of from 28 to 34 parts zinc and 72 or 66 parts copper. Gun metal contains 90 parts copper and 10 parts tin, while bell metal has a larger proportion of tin; ordinary bronze consists of 91 parts copper, 2 parts tin, 6 parts zinc and 1 part lead, but there are many kinds of bronze, each having a different composition from that given.

An alloy of copper and aluminum known as aluminum bronze resembles gold so closely that it has been quite extensively used in the manufacture of "gold" watch cases and other articles of ornament. Those who buy the articles usually pay dearly for what proves to be very poor gold. Another alloy of copper zinc and nickel is commonly known as German silver, and when polished looks very much like silver. Nickel-plated ware and objects made from aluminum have now replaced nearly all articles before made of German silver, so we seldom see it.

The compounds of copper are also very numerous, though we do not always recognize them, because they are so different in every way from metal. One of the most common of these is blue vitriol, which is a compound of copper and sulphuric acid, and is known as sulphate of copper or copper sulphate, as you choose to call it. The copper used

in electroplating is obtained from a solution of blue vitriol. This compound is also extensively used in dyeing and in charging electric batteries used in operating the telegraph. Compounds of copper and arsenic and the carbonates of copper usually have a beautiful green color, and many of them are used for paints. You can now see why most green paints are so poisonous. When copper or bronze are exposed to damp air for any length of time a variegated green coating forms on the surface. This substance is often known as verdigris, and is a compound of copper and acetic acid, such as makes vinegar sour. Verdigris is exceedingly poisonous, and it is formed whenever fruit or other sour substances containing this acid are left in copper or brass vessels for any length of time, hence it is not safe to use copper vessels for cooking such articles. The green effect on statues and other objects made from bronze is frequently produced by the use of acids to give them an antiquated appearance.

The United States now leads the world in the production of copper. In 1900 the out-put amounted to 606,117,366 pounds and was valued at $98,494,039; of this quantity the Lake Superior mines produced about 26 per cent, the Montana mines about 40 per cent, the Arizona mines about 23 per cent, and the small mines the balance.

ZINC.

Zinc in its pure state was not known to the ancients, though for centuries its ores were used in the manufacture of brass and bronze. It may seem

strange that the ore of a metal could be used in this way when the metal itself was unknown, but this is easily explained. Zinc ore is always in the form of rock, and the makers of brass and bronze among the ancient Babylonians, Greeks, Romans and other peoples discovered that by reducing this rock to a powder and mixing it with molten copper, brass could be made, and for many centuries this process was in use in the manufacture of brass and bronze.

Of all the metals in common use zinc is by far the most difficult to obtain in the pure state, and for this reason it came into use much later than gold, silver and copper. Pure zinc was first manufactured for use in 1721, and by 1737 its manufacture was well established in England. The first zinc produced in the United States was made at the United States arsenal at Washington, in 1838, but the process was so expensive that the work was soon abandoned. In 1850 the regular manufacture was successfully begun by the New Jersey Zinc Company, and the industry has continued to increase, until now the United States manufactures nearly one-fourth of the zinc produced in the world.

ZINC MINES.

The oldest zinc mines in the country are in New Jersey and in Lehigh Co., Pennsylvania. Later, deposits of ore were discovered near Knoxville, Tenn., in Arkansas, in the southwestern part of Wisconsin, and in Missouri and Kansas. Much of the ore found in Wisconsin and Missouri is smelted in Illinois and Indiana on account of the supply of coal and natural gas in those states.

The most recent and also the greatest development of the zinc industry has been in the vicinity of Joplin, Missouri, and the neighboring district in Kansas. Extensive deposits of very rich ore have been recently discovered in this locality, and the expense of working it is reduced to a minimum by the presence of natural gas. These conditions give the Joplin district advantages such as no others enjoy, and we find as a result that Kansas now produces more zinc than any other state in the Union. The other leading states are Illinois, Indiana and Missouri. The older mines in the Eastern and Southern states have lost their former importance, and taken altogether do not now produce as much as one of the states named.

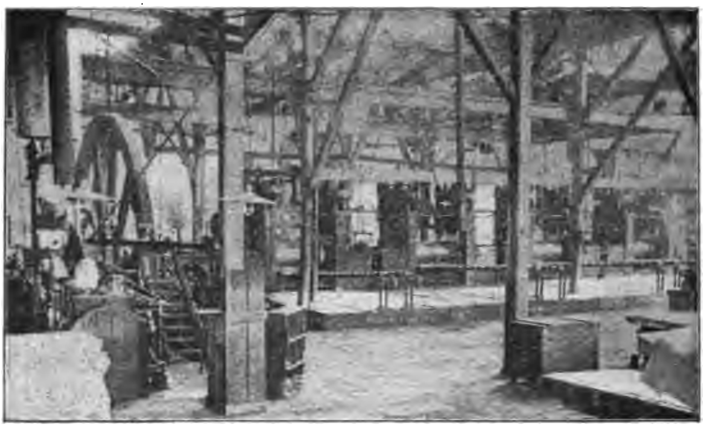
SMELTING.

Zinc ores are compounds of zinc with sulphur, carbon or oxygen, and the process of extracting the metal from them is a very complicated and difficult one. The sulphides and carbonates are first roasted to drive off the sulphur, carbonic acid and water. The roasted ore is then crushed fine and mixed with fine coal or coal dust in proportions of about six parts of ore to four parts of coal. This mixture is placed in a furnace made specially for the purpose, and heated.

The zinc melts and changes to vapor at a lower temperature than is necessary to liberate it from the ore, hence the process is called distillation. The zinc rises in the form of vapor, which passes cut through tubs in the top of the furnace and is collected in chambers having a temperature low

enough to change the vapor to liquid zinc, which is gathered in a tank on the bottom of the chamber. The molten metal is drawn off and cast into ingots.

Zinc obtained from the smelter usually contains more or less sulphur and arsenic, and needs to be redistilled before using. When purified it is melted and worked into the form desired. Sheet zinc, which is the most common form of the metal, is made by passing the hot zinc between successive sets of rollers, each of which makes the sheet larger and thinner than the one before. Other



INTERIOR VIEW OF A ZINC ROLLING MILL.

forms are made by pouring the melted zinc into moulds and castings it after the manner of casting iron.

PROPERTIES AND USES.

Zinc is of a grayish-white color, but if scraped or filed the exposed surface is nearly as white as

silver. The ordinary appearance is caused by a thin coating of oxide which forms on the surface when the metal is hot. This coating is an advantage, as it protects the zinc from the action of air and water. The degrees of hardness and brittleness depend upon the temperature. When cold, zinc is hard and very brittle, but on warming to about the temperature of boiling water, it becomes soft and malleable and can be rolled into sheets. If the temperature is raised, however, the brittleness returns. When cooling from the melted state zinc has a strong tendency to crystallize, consequently zinc castings have but little strength, neither is the metal suitable for making wire.

The most common use of zinc is in the form of sheets, which are employed for numerous purposes familiar to all. Another extensive use is in making parts of galvanic batteries. The place which zinc fills in the production of electricity is very important, for it is by the action of the acid in the battery on the zinc that the electric current is generated. Galvanized iron is made by passing sheet iron, which has been chemically cleaned, through vats of melted zinc. The mottled appearance of galvanized iron is due to the crystals of zinc formed when the metal was cooling. The coating of zinc protects the iron from corrosion by air and water, and renders galvanized iron valuable for making vessels used for holding water, for covering roofs of buildings, and making water spouts and many other articles of common use. Water for drinking puposes should not, however, be allowed to stand in galvanized iron vessels, for more or less

of the zinc dissolves into the water, and when taken into the system zinc acts as a poison.

The important alloys of zinc have already been described in connection with the alloys of copper, but zinc forms several compounds with substances other than metals that are of considerable importance in the arts. Zinc sulphate or white vitriol acts as a powerful emetic, and is sometimes used in medicine. Zinc chloride or butter of zinc is of great value in preserving wood that is exposed to the action of water. Zinc oxide, under the name of zinc white, is used for a paint for interiors, and has the greatest commercial importance of any of the compounds. It is now made directly from the ore, but was formerly produced by burning zinc in closed chambers and collecting the oxide. Zinc white is the best substitute for white lead.

The manufacture of zinc cannot be considered as one of the important industries of the United States, for the value of the entire output will not exceed $6,000,000 a year, but the relation which zinc sustains to other metals that form the basis of some of our greatest industries is such as to make a knowledge of its properties and uses necessary to a good understanding of these industries; for that reason zinc is given a place in this chapter. A review of the chapters on metals will show you how closely each is related to all the others in supplying our wants.